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(WITH ABSTRACTS)

CONTENT

TECHNOLOGY DEPLOYMENT STRATEGIES TO ENHANCE PERSONALISED LEARNING IN SINGAPORE'S HIGHER VOCATIONAL EDUCATION

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Abstract

Personalised learning has been of great interest in the educational sector for its benefits in customising learning based on individual student's needs. However, implementing personalised learning in a class is always a challenge to teachers because of the heavy resources and effort required to efficiently run it. This research was conducted to explore possible implementing strategies using educational technology, which support teachers in efficiently and effectively introduce personalised learning in a large class. Through an action research approach, personalised learning with technology was conducted over two weeks in a large class setting to observe its implementation practicality. Using mixed method data collection, quantitative and qualitative data were gathered from students and teachers for analysis. The data presented empirical evidence that technology enhanced personalised learning can be successfully implemented in a large class to support student's learning and teacher's resources. A significant amount of time was saved on teacher's teaching tasks, which allowed time for teachers to provide individualised feedback to their students. Although students and teachers had issues with their goal setting and tracking learning progress in their first week, evidence showed that they were able to overcome these issues in the second week.

Keywords: *technology enhanced personalised learning, personalised education, personalised feedback, higher vocational education, Microsoft Teams*

1. Introduction

Personalised learning theory was seen to have started since the 1950s and 1960s while it was only in the last two decades that it started to get interest from researchers to look deeper into this topic (Murphy, 2016; FitzGerald et al., 2018b). However, in FitzGerald et al.'s (2018b) paper, they indicated that only a total of eighteen research was conducted on this pedagogy from 2000 to 2017 targeting secondary and higher education learners, indicating a lack of research done to gain deeper understanding on the use of personalised learning in the academic setting. Furthermore, it was only in 2018 that the Australian government is looking at redeveloping their nation-wide curriculum to incorporate personalised learning (Reid, 2019). The given information suggests that personalised learning approach has not been fully studied and developed until the emergence of technology readiness in the past decade.

Personalised learning is known to motivate learning needs by allowing students to learn at their pace and capacity. Research has shown that learning as a class is not always ideal because every student has different learning characteristics (Bartle, 2015; FitzGerald et al., 2018a; Kaminskiene & DeUrraza, 2020; Holmes et al., 2018). In addition, Kapp (2016) highlighted that structured curriculum and lesson time restricts students from reflecting and discovering their personal learning needs. As a result, students seldom internalise the content taught in class and apply their learning.

While personalised learning is favourable to student's learning experience, other existing research papers highlights the difficulty in setting up a personalised learning in a large class environment (Chatti & Muslim, 2019; Bartle, 2015; FitzGerald et al., 2018a; Waldrip et al., 2016; Holmes et al., 2018;). Personalised learning by itself is complex, and that poses a challenge lies in adopting appropriate technology to create a personalised learning environment as well as collecting empirical evidence to evaluate its effectiveness (Chatti & Muslim, 2019; Holmes et al., 2018; FitzGerald et al., 2018a). Therefore, these research papers suggest that further practical experiments on TEPL is necessary to attain deeper comprehension on its effectiveness and limitations.

Much research was conducted to broadly discuss the use of personalised learning to improve student's learning motivation and experience, while only a few research papers discuss on the delivery approach (Bartle, 2015; FitzGerald et al., 2018a; Kaminskiene & DeUrraza, 2020; Holmes et al., 2018). In a personalised learning environment, a significant amount of teacher's involvement is required to provide attention to every student in the class, resulting in an increase in teacher's workload and stress (Chatti & Muslim, 2019; Holmes et al., 2018; FitzGerald et al., 2018a).

Singapore's education, despite being proactive in improving the quality of student's learning, is hit with impasse in their attempt to implement personalised learning. Their local polytechnics normally have an

average class size of twenty-three students to one teacher, which results in teachers having less time and attention to individual student's learning (Ministry of Education, 2020). Although Singapore is seen to be encouraging the education sector to adopt innovative technologies to enhance students' learning, implementing personalised learning with technology raises concern among many teachers (Asfa-Wossen, 2020; Chin, 2016).

From these articles, implementing personalised learning is deemed to be challenging in Singapore's higher vocational institutions because of the large class size and heavy resources to effectively deliver it. Hence, this research aims to explore existing educational technology that could support personalised learning and identify strategies to assist teachers in implementing personalised learning conveniently in Singapore's polytechnics. As such, the following three research questions (RQ) were studied:

1. What are technological and pedagogical strategies to consider when implementing personalised learning on skill-based subjects?
2. To what extent can existing technology help educators productively implement personalised learning effectively?
3. To what extent is personalised learning effective for a big class setting?

2. Literature Review

2.1 Implementation Considerations

Although personalised learning consists of only three main phases, which are goal setting, executing, and evaluating, the process can be complex when implementing in class (Chatti & Muslim, 2019). In FizGerald et al.'s (2018b) research, a student's learning goal is the driver for their learning activity because it is linked to the student's aspiration and learning need. This is effectively achieved by analysing the desired learning outcome with the skills needed to achieve it, which in turn identifies the student's learning activity to address their knowledge gap. However, the goal setting process is deemed challenging to students and requires co-creation and close guidance by the teachers (Sota, 2016a; Kaminskiene & DeUrraza, 2020). Therefore, for a class to implement personalised learning, technology tools should be used to resourcefully support both students and teachers in crafting an appropriate learning plan.

Personalised learning is known to encourage independent learning, but this ability should be taught to or practiced with the students. From Chatti & Muslim (2019) research, they closely relate personalised learning with self-regulated learning, where students should have the ability to organised and plan their learning. On the contrary, Sota (2016a) highlighted that the students may not have the skills to source for the right learning content for their learning activity. Layng (2016) identified this intricate process as a metacognitive competency, which is the student's capability to evaluate their planning and actions. Therefore, teachers are still required to teach and guide students in a TEPL environment, which develops student's metacognitive competency in parallel with the learning objective.

Evaluation of a student's personalised learning progress requires a huge amount of involvement from teachers. Mahon (2016) stressed the importance of providing feedback when it is given immediately upon a student's learning activities, which allows students to act upon it and improve their learning. Furthermore, FitzGerald et al. (2018b) mentioned that TEPL could be used to support teachers in providing some automated feedback, which in turns allow teachers to concentrate on qualitative comments for the students. Therefore, the implementation of TEPL requires careful design of the feedback system to assist teachers in providing immediate and frequent feedback, and possibly offload teacher's involvement is low level feedback through automation.

Social learning is an important aspect of students' learning, which is essential to be included in a personalised learning environment. In Melzer & Schoop (2018) research, they mentioned that peer learning is an important feature in personalised learning environment because students can learn important information through discussion and collaboration. In addition, Major & Francis (2020) recommended teachers to focus their effort in facilitating group learning and discussion in a personalised learning environment, which enhances student's social learning skills. These research papers suggest that apart from aiming to achieve academic success, a student's learning experience should encompass activities that nurtures their personality. As such, a TEPL environment should promote social learning by providing functionalities that conveniently allow teachers and students to interact and socialise.

2.2 Users' Experience

From a student's perspective, TEPL plays a learning assistant role to support student's learning needs after class. Major & Francis (2020) indicated that immediate feedback is made possible for students using technology, which proves to be useful when teachers are not available for their students after class. Moreover, in Lim et al.'s (2020) research, using technology to provide analytics-based feedback assists students to keep track of their learning progress and recall the details of their homework. This research suggests that TEPL should support students in self-regulating their learning especially after class. Hence, a TEPL environment should possess the functionality of providing frequent learning reminders and immediate feedback, acting as a learning assistant after class.

In a personalised learning environment, Sota (2016b) mentioned that the role of a teacher shifts from teaching to coaching or mentoring their students. Flipped classrooms are examples of allowing students to learn at their own pace with the use of online learning platforms. As students return to the class, teachers could spend lesson time to review students' learning progress and facilitate meaningful discussion (Fuchs, 2021). With the appropriate use of technology, teachers could spend less

time on repetitive administrative tasks and dedicate more time to provide quality feedback to students (Redding, 2016). Therefore, these research papers suggest that a TEPL environment should include the capability of offloading teacher's repetitive teaching and administrative tasks. In return, teachers could spend their time to provide students with personalised feedback, which enhances their personalised learning experience.

2.3 Existing Technology Limitations

While implementing TELP revolves greatly around enhancing student's learning experience, little consideration was given to other stakeholders. Holmes el al. (2018) illustrated a framework of analysis to consider when implementing TEPL, which includes the questioning on why, how, what, when, who and where to personalise the learning for students. Similarly, Chatti & Muslim (2019) broadly categorised the Seven Stages of the Personalised Learning Activity Cycle into goal setting, execution, and evaluation. These frameworks demonstrated the need for the school to thoroughly design and plan out personalised learning in the context for students and curriculum before implementing it.

However, FitGerald et al. (2018b) discussed the six aspects of personalised learning framework with an additional consideration on the impact of TEPL on all the stakeholders. Apart from the fundamental focus to improve student's learning experience, implementing TEPL should also consider the benefits for teachers, trainers, and schools. Some examples shown were large scale student's performance tracking, understanding learner's behaviour and providing additional learning support to students. Moreover, Bartle (2015) highlighted that educator may lack the necessary skills to deliver personalised learning. This could be due to the overly complicated pedagogical framework and operating sophisticated learning technology. Yet, there is a lack of research discussion on strategies to implement TEPL that could be easily adopted by educators and support their teaching challenge.

These research papers emphasised the lack of features in existing technologies to support teachers in conveniently adopting personalised learning to enhance students' learning experience. Therefore, further research on this gap would be recommended to identify existing technology that support teachers in implementing personalised learning and strategize low effort and resources in adopting personalised learning in a large class. The selected technologies should offer features to reduce teacher's mundane tasks and encourage teachers to facilitate social learning in class.

3. Methodology

3.1 Research Approach

The participants for this research were a purposive sample taken from a cohort of 65 second year students from a Singapore's polytechnic, aged between 18 to 21. As the average class size of this sample was 22, it fit the research investigation of a large class size where implementing personalised learning is deemed challenging.

This research adopts an action research approach to conduct experiments and gather data to analyse against TEPL theory. Ivankova (2014) highlighted that action research guides practitioners in gaining deeper insights of the research questions by conducting a series of focused testing and expository thinking. Since this research seeks to suggest effective solutions to implement TEPL, the action research cyclical process reviews the problem from the feasibility perspective while keeping personalised learning pedagogy in consideration.

This research was initiated by setting up TEPL using Microsoft Teams (MS Teams), which is readily available within the organisation. Adopting Chatti & Muslim's, (2019) seven stages of the personalised learning activity cycle, MS Teams and its build-in software acted as a learning management system, which supported students and teachers with personalised learning (Table 1). In addition, the six dimensions of personalisation mentioned in FitzGerald et al.'s (2018b) research were taken into consideration. Additionally, the sixth dimension (impact) was elaborated in Table 1, taking both students and teachers into account. Investigation on the teacher's beneficiary was targeted to answer RQ1, which is exploring strategies to improve teacher's productivity and easing the implementation issue.

Table 1

7 Stages of Personalised Learning Activities	**(who) Student**	**(who) Teacher**	**Technology implemented**
Goal What is the final outcome?	(what) personalised project outcome (char) interest, level (how) self-described	(what) aligning learning outcome	**OneNote** – student's goal setting, review and feedback by teacher.
Plan How should I schedule?	(char) level and self-regulation (how) self-described	(what) regulate learning, feedback	
Specify What should I learn?	(what) choice of learning content (char) level, interest (how) cognitive	(what) provide necessary learning resources	
Perform How do I learn?	(what) watch video and practice along (char) learning mode (how) cognitive	(what) recorded teaching, (how) social learning	**- Online learning videos** **- Chat channel**

Perceive What have I created?	(what) self-assessment (how) whole-person	(what) feedback on learning outcome	**OneNote** – student journaling results, review and feedback by teacher. **Excel** – teacher tracking students' progress.
Interpret How much have I learnt?	(what) reflect on learning approach (how) whole-person		
Compare Is this scaffolding to my outcome?	(what) reflect on goal progression (how) whole-person		

3.3 Data Collection

Mixed method data collection was applied with the action research process to investigate the research questions. A set of questionnaires were used to collect both quantitative and qualitative data through online forms over two weeks from the class and the teacher after the lesson. These quantitative data collected served as empirical evidence to answer RQ2 and RQ3, which were gauging the effectiveness of deploying TEPL in a large class from teachers and student perspective. Open-ended questions were used in at the end of the questionnaire to collect qualitative data (Wellington, 2018; Coe, 2017). These questions allowed participants to share their emotions or voice out their concerns, providing quality inputs for RQ3 (Cohen et al., 2017; Opie & Brown, 2019).

Interviews were conducted with the teacher and students each week to provide synthesis with the quantitative data from the questionnaire (Ivankova, 2014). Through a ten-minute interview discussion, causation and affective related details that were not easily captured through the questionnaire can be better expressed by the interviewee verbally. As such, the interview was an appropriate instrument for the teacher to articulate their thoughts and concerns. However, Opie & Brown (2019) highlighted that not everyone is comfortable with interviews. Hence, only students who voluntarily provided consent were contacted for the interview (BERA, 2018).

3.4 Data Analysis

Quantitative data were analysed through simple descriptive statistics that illustrate empirical evidence based on the research activities (Opie & Brown, 2019). The data were categorised into four main segments for a meaningful interpretation, namely: feelings, effectiveness, interaction and technology (Cohen et al., 2017). These quantitative data formed the foundation to answer the three research questions from a surface perspective. The qualitative data collected from the interview transcripts were processed with thematic analysis. Since the interviews were conducted to further understand or confirm the findings from quantitative data, the themes discovered from the transcript provided a categorisation for the rationale supporting the quantitative data (Opie & Brown, 2019; Cohen et al., 2017).

With the analysis from both quantitative and qualitative data, triangulation from these sources was reflected upon, providing the breadth and depth to answer RQ1 (Ivankova, 2014). Kurniawan (2018) mentioned that triangulation happens when interpretation of both qualitative and quantitative data is possible through convergence, differentiating or both. As such, the quantitative data collected in this research was cross validated with the qualitative data to interpret the causation of the event. Hence, the quantitative data provided an avenue to translate into qualitative data for discussion, which contributes insights to answer RQ1.

4. Results and Discussion

RQ1: 'What are technological and pedagogical strategies to consider when implementing personalised learning on skill-based subjects?'

The personalised goal setting process was impacted by students with weak learning motivation. While TEPL had been effective for most of the students, this research data showed that one-third of the students were seen to have issues with their learning motivation. From student's feedback, three potential reasons that reduced their learning motivation were student's study load, stress and time management. Relating back to the Literature Review, some students might not possess the necessary skills to be independent learners, which includes planning, problem solving and evaluation (Sota, 2016a; Layng, 2016). Therefore, implementing TEPL would need to consider imparting these metacognitive competencies to the students.

Secondly, TEPL could create individualised learning due to low interaction among the students and teachers in the class. From these research findings, most of the students were seen learning individually as the content they chose was different. Thus, students' interaction was reduced tremendously because they have less or no common topic to discuss on, which creates individualisation. As outlined in the Literature Review, social learning is critical in students' learning because through human interaction, students can develop their personality, learn and collaborate with their peers (Melzer & Schoop, 2018; Redding, 2016). Yet from this research, the social learning aspect in TEPL did not occur naturally. The teacher spends most of his time providing personalised feedback and he felt that he had less interaction with their students. Therefore, another consideration for TEPL implementation should include time and activities to be allocated in the lesson plan for teachers to facilitate social learning.

RQ2: 'To what extent can existing technology help educators productively implement personalised learning effectively?'.

MS Team had helped teachers to implement TEPL effectively in most aspects. In this research, teachers'

productivities were improved as they were able to provide personalised feedback to their classes as well as on-demand learning guidance. As teachers leveraged on OneNote to provide personalised feedback with lesser time, the time saved can then be utilised to support students who needed guidance. This finding aligned with the Literature Review, where teachers make use of TEPL to perform repetitive tasks to provide quality feedback to students (Redding, 2016). Additionally, in this research, although teachers felt challenged on their first attempt, the teacher agreed that TEPL was effective and achievable on the second week. Referencing the Literature Review, teachers might resist implementing new teaching approaches because of the complex technology platform (Bartle, 2015). Hence, adequate preparation through learning and familiarisation with the platform is necessary prior to implementing TEPL, as this process equips teachers with the required skills to confidently deliver personalised learning.

Conversely, the monitoring process of student's learning could be further improved in the TEPL environment. This research found that teachers lacked time in monitoring student's in-class learning as they were occupied with providing feedback to students' previous work. This is crucial as highlighted in the Literature Review, that students may not be capable of planning or taking actions for their choice of learning (Sota, 2016; Layng, 2016). Furthermore, the research findings suggest teachers should focus their monitoring on weaker students because they tend to get distracted and unmotivated in their learning easily. This coincides with the Literature Review that teachers change their role to a coach or mentor in a personalised learning environment (Sota, 2016b; Major & Francis, 2020). Therefore, based on the research evidence, a TEPL needs to support teachers in monitoring student's learning effortlessly. Such features would increase teachers to students' interaction during class and improve the mentorship quality in the TEPL environment.

RQ3: 'To what extent is personalised learning effective for a big class setting?'

TEPL had been effectively implemented in a big class setting because most of the students were comfortable with personalised learning approach. From the research data, all students were satisfied with their personalised feedback, which was given in both weeks. The weekly feedback had helped the students to gauge their learning and improve themselves. Referencing the Literature Review, frequent quality formative feedback supports students to understand their learning progress over time (Mohan, 2016; Sota, 2016a). This in turn encourages students to regulate their learning and take actions to further improve their mastery.

Additionally, from this research, more than 90% of the students indicated that they were capable of learning independently for both weeks, as they were able gauge their learning progress and achieve their goal. This was outlined in the Literature Review that quality feedback helps students achieve their learning goal because they can monitor their performance and stay focused to accomplish their target (Sota, 2016a). Summarizing from this discussion, frequent personalised feedback provided to students creates a strong learning satisfaction. This was made possible in a large class because the TEPL environment enabled teachers to efficiently provide quality feedback to the students.

Out of the three stages of personalised learning, goal setting was seen to be the most challenging phase. From the research findings, 20% of the students had issues with their goal setting process and required more guidance. These students did not feel that they had a clear plan to achieve their goal because of their study stress and time management capability. Similarly in the Literature Review, goal setting was highlighted to be a difficult process in personalised learning as students may not possess the competency to plan for themselves based on their existing capability (Sota, 2016a; Kaminskiene & DeUrraza, 2020; Holmes et al., 2018).

Furthermore, 10% of the students indicated that they have difficulty locating or choosing the appropriate resources for their learning. Although learning resources were provided for students to learn, some students prefer to search for external training videos tutorials. Referencing the Literature Review, students may not be resourceful enough to search for appropriate resources based on their prior knowledge (Layng, 2016; Sota, 2016a). This is because some students have yet to develop their metacognitive competency to evaluate the suitability of the solution to their situation. Synthesising from the discussion, the goal setting process can be difficult for the students because some students do not possess the planning and evaluative skills. Hence, implementing TEPL in a large class setting was effective only if all students are equipped with the necessary metacognitive competency.

Conclusion and Recommendations

A technology implementation framework could be formulated, to assist the evaluation and designing of new technology for educational purposes. In this research, only MS Teams and it's given features were used to implement TEPL to the students. Although the success in implementing this research was high, there were some areas that were hindered by MS Teams limitation. For example, the goal setting process was not intuitive for students and monitoring of student's learning was not efficient. Therefore, a well-designed framework is necessary to support better decision making in implementing TEPL in class. The framework should consider both teachers and students user experience so that the technology fits their needs.

Metacognitive competency should be considered as part of the personalised learning process. TEPL may not be suitable for all students because this learning approach requires a certain level of metacognitive competency, which includes time management, planning skill, self-regulated learning motivation and problem-solving skill. One of the significant challenges discovered from this

research was weaker students managing their study load. As these students were not able to arrange and balance their study load from various subjects, in turn the students were demotivated with their learning. As such, it would be recommended for future personalised learning studies to consider incorporating building student's metacognitive competency as part of student's learning. Through strengthening student's ability to learn independently, they could possibly be more resilient towards small impasses that could hinder their learning.

Limitations

The scope of this research is limited to behaviourism learning and did not include cognitivism or constructivism learning. Students in this research were learning a skill-based subject, which requires more hands-on learning activities rather than thinking and application activities. Therefore, the amount of personalised feedback required from the teachers to guide students learning in a behaviourism learning could be potentially higher as compared to cognitivism or constructivism learning.

This research paper's findings represented teenager's demographic in higher education and may not apply to primary or secondary students. As highlighted in the Literature Review, TEPL requires students to possess a certain level of self-regulated learning to effectively learn independently (Sota, 2016a; Layng, 2016). However, such metacognitive competency may not be developed in younger students due to their level of maturity. Hence, this research paper is limited to provide findings on TEPL implementation only for teenagers in higher education.

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CDIO INTEGRATED LEARNING EXPERIENCES IN PROCESS SAFETY USING DIGITAL TECHNOLOGIES

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Abstract

This paper shares the work done in using digital technologies – namely Interactive Video and Digital Twin – to development process safety awareness among students from the Diploma in Chemical Engineering, Singapore Polytechnic. The work involved the creation of 2 "virtual plants" that replicates 2 actual physical pilot plants in the workshop. This work is part of a greater initiative to inculcate a safety mindset among our students, so that they can work effectively as process technicians in the chemical processing industry. In these activities, students are required to use a plant's Piping and Instrumentation Diagram (P&ID) to carry out line-tracing, and identify potential process safety hazards. These "virtual plants" provide students more opportunity to learn at their own pace, and not subjected to the rigidity of workshop opening hours to perform the task with the physical plants. In later part of the semester, they are required to physically operate various pilot plants, and their skills in performing line-tracing effectively and identifying various process safety hazards will be put to the test. The development work is timely, as the Covid-19 pandemic can result in prolonged campus closure, jeopardising students' learning opportunities in accessing the physical pilot plants. The software packages also helped addressed any applicable needs for safe distancing. As events unfolded, when the 2 software packages are ready for use, students were permitted to return to campus for activities that require physical presence. Hence, in the pilot run, the author managed to engage the students in using the 2 software packages in the workshop; and then to visit the physical plants to make a quick comparison of the two modes of learning. This paper first briefly shares the importance of process safety, and explains how integrated learning experiences are designed using the CDIO Framework (www.cdio.org) with core principles of learning as guidance. This paper also shares students learning experience with the 2 software packages, and shed some lights into their preferences, most notably in terms of delivery mechanism in the event of campus closure: either in synchronous or asynchronous manner.

Keywords: *Process Safety, CDIO, Interactive Video, Digital Twin, Integrated Learning Experiences*

Importance of Process Safety

Safety is of paramount importance in the chemical processing industries, given that they deal with many different chemicals of various toxicity many of which are also flammable; and often at high temperatures and pressures. Broadly speaking, safety can be classified into workplace safety (also known as personal safety or occupational safety) and chemical process safety (or just process safety in short). Most people are more familiar with workplace hazards, which are often visible and readily perceived and understood; the nature and scale of a potential injury – for example from a fall – is easy to imagine. Process hazards on the other hand, are less intuitive, so hazard identification techniques need to be structured. Although some process hazards might be easily perceived, such as leakage of chemical from a corroded pipe work for example, many hazards are not so visible and not intuitive – for example, the sequence of events following a loss of containment whether due to human error (such as not following operating procedures) or equipment failure.

Process Safety: Line-tracing using P&ID

Teaching of process safety is integrated into the practical component of the core module *Laboratory and Process Skills 2 (LPS2)*, taught to Year 1 Diploma in Chemical Engineering (DCHE) students in Semester 2. This module is part of a suite of 4 skills-based modules in the revised DCHE course structure featuring a spiral curriculum (Cheah & Yang, 2018). Besides developing skills in laboratory analysis and process plant operations, these modules also serve to inculcate in students a safety mindset (Yang & Cheah, 2020). Safety awareness in laboratory setting is instilled in Year 1 Semester 1 in *Laboratory and Process Skills 1*, where students learn about Job Safety Analysis and using the correct personal protective equipment, a key aspect of workplace safety. In *LPS2* they are now required to learn about process safety, before operating various pilot plants to gain experience as process technicians. Teaching of process

safety takes place alongside the students' learning of Piping and Instrumentation Diagram (P&ID) and line-tracing, 2 key competencies for process technicians.

The P&ID is the blueprint of a chemical plant, it uses symbols to represent how the actual plant will be constructed, for every plant item ranging from equipment to valves and instruments, to all pipes, piping components and fittings. Line-tracing is the process where a chemical engineer or process technician uses a P&ID and literally "walk the line" in the plant, checking every item in the plant against that shown in the P&ID. Every discrepancy noted will need to be reconciled. Line-tracing is useful not only in helping an engineer or technician get familiar with a given chemical plant, it is also serving an important role in promoting critical thinking necessary in understanding process safety. When tracing a line, the engineer or technician needs to know what is flowing inside the pipe (gas, liquid, or mixture), their properties (such as flammability, corrosivity, etc), operating conditions (mainly pressure and temperature, among other process variables), the direction of flow from equipment to equipment and the changes that happens (e.g. reaction, heating or cooling, or phase changes, treatment, separation, etc), sampling and/or sample collection points, any deliberate or potential discharge, for every pipe in the chemical plant.

Having a safety mindset during line-tracing is essential for the engineer or technician to "see the unseen" (Abramnowicz, et al, 2019). Having complete knowledge at any given time is important during normal operation, should a process upset (e.g. flange leak, pump seal failure, etc) happened. During operation, a valve may be wrongly opened or closed, so one needs to be aware of the potential consequences of such mal-operation. During plant shutdown where maintenance works need to be carried out, line-tracing is important to ensure that proper positive isolations have been carried out, so that there will be no accidental ingress of chemicals. Proper line-tracing also ensures that all necessary sections of the pipes (and equipment) are properly drained of chemicals and purged free of any harmful hydrocarbons.

What are Integrated Learning Experiences?

Standard 7 Integrated Learning Experiences is one of the 12 Core Standards in the CDIO Framework (www.cdio.org) used to guide curricular design or redesign. More specifically, it is stated that "*Integrated learning experiences are pedagogical approaches that foster the learning of disciplinary knowledge simultaneously with personal and interpersonal skills, and product, process, system, and service building skills. They incorporate professional engineering issues in contexts where they coexist with disciplinary issues. For example, students might consider the analysis of a product, the design of the product, as well as the social, economic and environmental responsibility of the designer of the product, all in one learning experience.*"

In the context of this work, the integrated learning experiences combined within the same the learning setting the simultaneous application of technical know-how of reading a P&ID, using it to conduct line-tracing, and identifying potential process safety hazards, all at the same time integrating teamwork, communication, critical thinking and self-directed learning.

What are Core Principles of Learning?

There are various versions for core principles of learning being suggested. Here, the author uses Sale's 10 Core Principles of Learning (Sale, 2015), as shown in Table 1. Sale's core principles of learning are based on his extensive review of the literature on human learning and studies on effective teaching professionals in a range of educational contexts. The author adapted these principles to the context of teaching and learning using digital technologies. This was done via a literature review on the affordances of digital technologies in enhancing teaching and learning (Gadera & Zalipour, 2018; Brame, 2016; Kolas, 2015; Willmot, et al. 2012; Karppinen, 2005; Mayer & Gallini, 1990) identifying and aligning the findings to one or more core principles of learning, thereby integrating various best practices into a holistic approach towards an integrated learning experience for students.

Table 1. Sale's Core Principles of Learning

S/N	Core Principle of Learning
01	Learning goals, objectives and proficiency expectations are clearly visible to learners
02	Learners prior knowledge is activated and connected to new learning
03	Content is organized around key concepts and principles that are fundamental to understanding the structure of a subject
04	Good thinking promotes the building of understanding
05	Motivational strategies are incorporated into the design of learning experiences
06	Learning design takes into account the working of memory systems
07	Instructional methods and presentation mediums engage the range of human of senses
08	A psychological climate is created which is both success-orientated and fun
09	The development of expertise requires deliberate practice
10	Assessment practices are integrated into the learning design to promote desired learning outcomes and provide quality feedback

Design of Integrated Learning Experiences using Interactive Video and Digital Twin

Teaching of identifying process safety hazards via line-tracing is achieved via the design of 2 integrated learning experiences, one using digital twin (DT) and another

using interactive video (IV). The DT package is modelled after a neutralizing reactor pilot plant (see Figures 1 and 2), while the IV packaged is modelled after a shell-and-tube heat exchanger pilot plant (see Figures 3 and 4), both available in our workshop. Both are designed by applying the core principles of learning, to provide sufficient interactivity to engage students in their learning. Both requires students to use the plant's P&ID to carry out "virtual" line-tracing, where they first learnt of process safety hazards using the DT package, and 1 week later use the IV package to identify these hazards.

Figure 1. Actual Neutralizing Reactor Plant

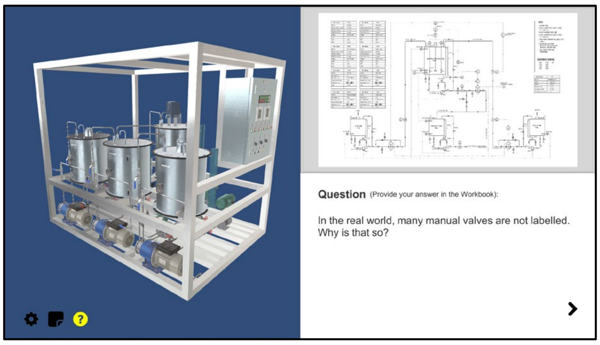

Figure 2. Digital Twin of Neutralizing Reactor Plant

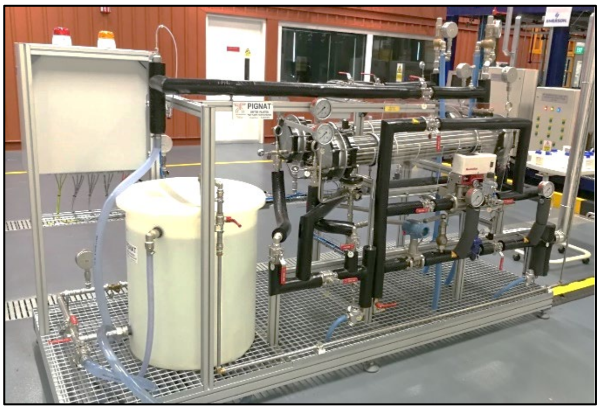

Figure 3. Actual Shell-and-Tube Heat Exchanger Plant

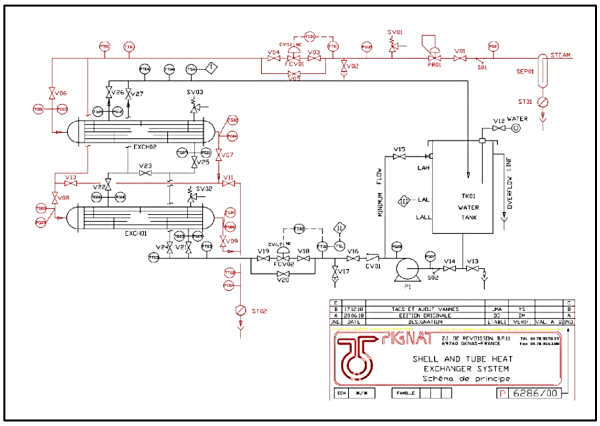

Figure 4. P&ID for Shell-and-Tube Heat Exchanger Plant

The rationale for using the neutralizing reactor is a straight-forward one. Neutralization is a concept already understood by all students from studying chemistry during their secondary schools. The choice of using a heat exchanger is also straight-forward: it is a common equipment used in every chemical plant: to heat or cool either gas or liquid streams or mixture of both to the desired operating temperature. As in operating any chemical plant, skills such as critical thinking, teamwork and communication are essential; not only to ensure successful start-up, shutdown, or normal operation of the plant. In this aspect, paying careful attention to potential process safety hazards is of paramount importance.

The rest of this section provides explanations on how the relevant CDIO Standards and Core Principles of Learning (CoP) are used to guide the design of the 2 integrated learning experiences (CDIO Standard 7).

CDIO Standard 1 (The Context) sets the scene for learning, i.e. students working as process technicians in a chemical plant. The learning outcomes (CDIO Standard 2 Learning Outcomes) are clearly defined in terms of desired performance standards and clearly communicated to students (CoP#1). The competency to be developed is structured for progressive development (CDIO Standard 3 Integrated Curriculum). Learner prior knowledge of P&ID reading and table-top line-tracing covered in earlier lessons in *LPS2* (Cheah, 2021) are activated to support new learning of identifying potential process hazards (CoP#2). To assist students in assimilating the new knowledge, all activities in both packages are broken down into manageable "chunks", and arranged in a logical sequence centred around key concepts that helps students understand the topics (CoP#3). In addition, a workbook was developed for each learning task to scaffold students' learning (CoP#3) as they go through the package, with the help of guiding questions (Lawson, et al, 2006). Through careful scaffolding and sequencing of the activities, these workbooks help with the 'chunking" efforts to reduce students' cognitive loads (Schwan, & Riempp, 2004). Prompts are used throughout both packages and the workbooks to stimulate thinking (CoP#4) and hints are provided as appropriate (CoP#5). Another motivational

strategy comes from the choice of neutralizing reactor plant itself. This plant has 4 storage tanks and correspondingly 4 centrifugal pumps, and hence the lecturer did the teaching of line-tracing using P&ID based on one set of tank and pump; and to demonstrate how process safety hazards can be identified. Students then get to practice this using different sets of tank and pump for slight different operation (CoP#9). This serves to enhance their motivation that they can successfully complete the task assigned (CoP#8). When the students move on to the IV package, they are then challenged to identify (CoP#4) new process hazards under a different context, as the equipment plant they will work on, namely the shell-and-tube heat exchanger, is not found in the neutralizing reactor plant.

Interactivities (Vural, 2013; Wouters, et al, 2007; Zhang, et al, 2006) introduced throughout the packages include a variety of methods, such as true or false questions, multiple choice questions, fill-in-the-blanks, move-the-mouse-and-click, drag-and-drop, etc. Some of these allows multiple attempts; and feedback are provided for both right and wrong answers. Herein lies the big advantage of using digital technologies: feedback can be given in a targeted and timely manner (Richtberg & Girwidz, 2019). More specifically, with regards to identifying potential process hazards, students are asked "what if" questions, using a template prescribed by the Singapore Workplace Safety & Health Council (WSHC, 2017). This approach requires that students first imagine how one would perform a task, before actually executing it (Kubovy, 1983). This will require students to integrate their generic knowledge on process safety hazards analysis and apply them in the specific operational context of a given chemical plant. Constructive alignment is applied to ensure that the assessment of their learning is based on their completion of the template.

Discussions of Student Learning Experience

As mentioned in the earlier section, students first go through the activities using DT, with the lecturer facilitating the line-tracing process and process safety hazards identification. Students record their learning in the workbook. In the following week, they carry out the process on their own guided by narratives in the IV and the workbook.

The initial intent of this work is to use digital technologies to complement student learning. As we are all too familiar, the Covid-19 pandemic disrupted learning, including this development work. Indeed the campus was closed for a prolonged period and all lessons had to be conducted online. As events unfolded, when the 2 software packages are ready for use, students were permitted to return to campus for work in laboratories or workshops, subjected to proper safe management measures. Hence, in the pilot run, the author managed to engage the students in using the 2 software packages in the workshop; and then to visit the physical plants to make a quick comparison of the two modes of learning.

To assess students' learning experience in using the 2 packages, we conducted a survey after the conclusion of the 2 learning activities. The survey used a combination of close-ended questions using 5-point Likert Scale; and several open-ended questions. A total of 83 students responded to the survey, out of 110 students from 6 classes; representing a response rate of 75.45%. The findings are shown in Figures 5 to 8.

The large percentages of students who rated the DT and IV as useful (Figure 5) for helping them with the intended learning outcomes (Figure 6) are encouraging. Such results reinforced earlier findings from cognitive psychology, for example the works of Shepard & Cooper (1982) who had made the connection between visual clues, the memory process, and knowledge acquisition.

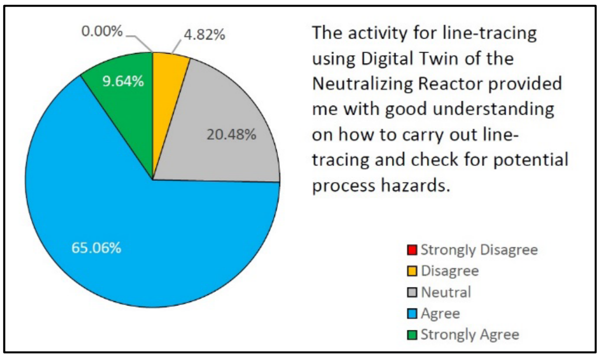

Figure 5. Usefulness of DT in learning process safety

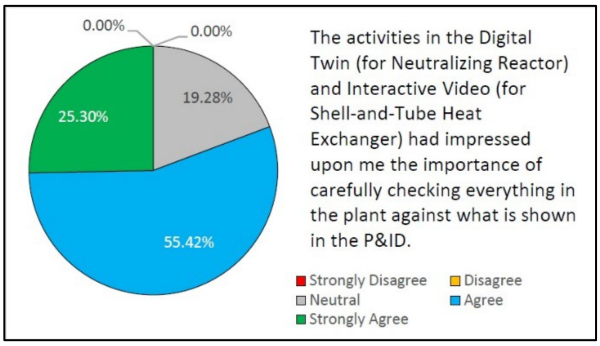

Figure 6. Usefulness of learning tasks using DT and IV

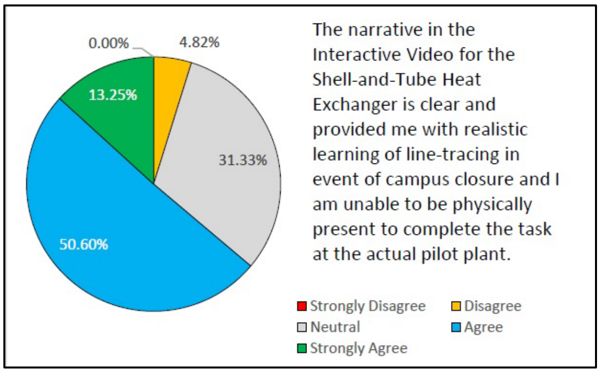

Figure 7. Usefulness of narratives in IV

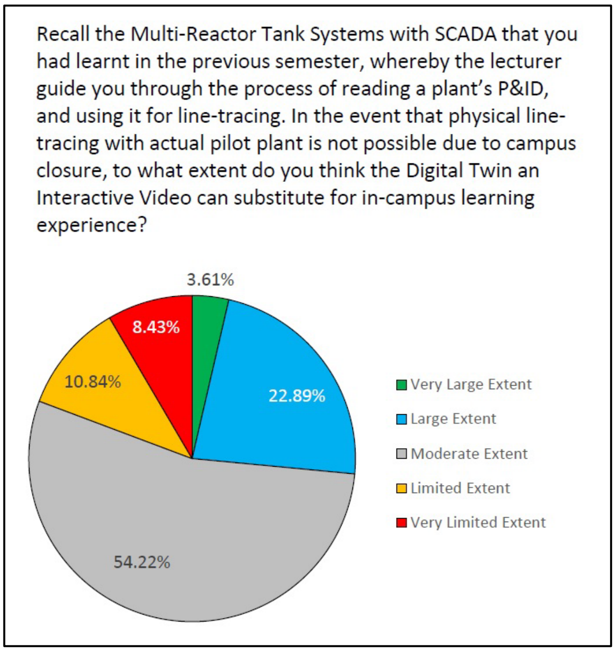

Figure 8. Perception of replacing using virtual plant vs physical plant for learning

Does this mean that the DT and IV packages can be used to replace actual on-site activities should the need for campus closure arise again? Even though a large majority of students agree that the line tracing experience using digital technologies are realistic enough to help them with their learning (Figure 7), this percentage dropped significantly when asked if these activities were to be carried out entirely online (Figure 8).

The survey also contains open-ended questions, one of which asked students to indicate and explain their preference, if any, for using DT or IV. Another question asked them for their preference, in the event that they had to learn from home, which mode of learning – synchronous or asynchronous. Only 19 students responded with entries to the open-ended questions, of which only 16 provided useful replies whereby a combinations of IV and DT is preferred. The reasons they provided confirmed what the author had intuitively knew about 'limitations' of IV vs. DT. The majority of these students (10 vs 6) also stated that they prefer the asynchronous approach; with many citing the ability to work at their own pace as the main reason. Those who prefer a synchronous approach mentioned opportunity to seek clarifications with lecturer as the main reason for their selection.

Moving Ahead and Plans for Improvement

The introduction of these learning activities was very timely indeed, as these software packages can be used should the campus be closed again in the future. Even if access to campus is permissible, the software packages can be used alongside the actual pilot plants, and can help to address any applicable needs for safe distancing. More importantly, given the students strong reservation of using the DT and IV as substitute for in-campus learning, and in the event that online learning still becomes necessary, preference for asynchronous learning; the author now contemplates the use of hybrid mode of learning moving forward for the next run of the module.

The author recognizes that there will always exist trade-offs in students' learning when contents best learnt via hands-on are moved completely in online format. This is particularly so for process technicians, as expertise or mastery results from physical presence in the chemical plant that engages all 5 senses. Technological developments in virtual reality (VR) held promises to enhance these, but needs to be supported by 5G network to overcome bandwidth constraint with respect to latency issues. Besides sights and sounds, there are still limitations of what digital technologies can simulate in terms of smell (e.g. the uniqueness of chlorine gas), or touch (e.g. tightness of a closed valve). Response in real-time is in particular an important considerations, especially in emergency situation; and the mere clicking of a mouse or dragging a slider to simulate valve opening will convey the wrong understanding to learners in actual time and effort needed.

Next, on the improvement of the 2 packages. The first iteration of the DT and IV packages is by no means perfect. Even before introducing them to students, the author had already noted many areas that can be improved on the prototypes developed, as new ideas that popped-up when he reviewed the package. As the Covid-19 pandemic is looming, the author decided to go ahead with the package, noting down the deficiencies to be improved upon in later iteration of the packages when the opportunity is available. It may not be so easy if a new programmer is tasked to carry out updates of packages done earlier by different person(s).

It is also worth noting that the DT package developed is only considered as a "basic-level" one, in that only the physical aspects of the pilot plant had been converted into digital version. The interactivities are created to depict visually how a fluid will flow in the plant, but these were not modelled mathematically as would be the case with a dynamic simulation system. Work is in progress to build another digital twin using a more complex pilot plant for Year 2 DCHE students. Due to budgetary constraint, the new digital twin package under development can only feature dynamic modelling that are still limited to that of "first principles" only, meaning that the modelling is only up to the "macro" level as predicted by the laws of thermodynamics. The model still does not have the high-level fidelity down to mimicking the behaviour of individual equipment. For example, in the case of valve opening, the model is not able to discern differences in valve characteristics, which affects how much a fluid can pass through based on the valve opening. Such application is an important consideration in guiding valve selection for emergency operation. Unlike the DT described in this paper, the new digital twin will be 2-dimensional in nature, again due to cost constraint. It

therefore is not capable of delivering the 3-D immersive experience as can be provided by VR.

Conclusions

This paper shared the learning points gained from designing integrated learning experiences for students to develop safety mindset in chemical plant operations using digital twin and interactive video. Feedback from students indicated that they prefer to use them to complement traditional on-side learning, rather than completely online.

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Build a scalable virtual learning platform with AWS AI services

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Abstract

Due to the COVID-19 outbreak, schools in various countries have changed from face-to-face teaching to online teaching. There are some problems with the existing online teaching solutions. The students share the assignments and cheating on online tests. Students digitally signed-in the meeting tool but not mentally engaged the lessons because they are distracted by their phone or gaming. The lonely learning environment also impacts their mental health.

The project "All Screens" is built to solve the above problems. All Screens is an online education application enabled with AWS Amplify, Amazon AI services and Amazon Sumerian to provide four functions. The teachers can gain insights into student productivity with "All Screens View". The Virtual tutor supports 55 languages and adapts expression based on the context of the discussion, it also able to answer subject specific questions. Teachers can use the "Work alone mode" during online tests to ensure the students work independently. The "Callouts" function enables teacher informs students with important message.

All Screens is used for two academic year at Hong Kong Institute of Vocational Education (Lee Wai Lee). As a result, the number of students taking online classes has dropped from 90% to 70%, but it can make sure that students has studied hard. AR assistant adds the fun for online classes through greater interaction, students can ask questions at any time. The problem of copying homework or cheating have been solved.

In concluded, All Screens makes virtual education easy for both students and teachers. It helps student focus on class and improves students' productivity since they are on longer able to copy assignment and cheating in tests. It also improves engagement and provide empathic two-way dialogue.

Keywords: *AWS, amazon, cloud, AI, machine learning, AWS rekognition, amazon sumerian, AWS amplify, VR, chatbot*

Introduction

My institution turned into online teaching after the COVID-19 outbreak. Most of the existing online teaching solutions are designed for online meeting or single direction broadcast. Teachers are difficult to monitor the students' learning status. Students are easily distracted from other sources. Therefore, our school has developed "All Screens" for teachers to use. This is an open source project, and all schools around the world can download our code. All Screens is an AWS Amplify App using most of the Amazon AI services and Amazon Sumerian to address the problem. This project is the extension of Lab Monitor (AWS Artificial Intelligence (AI) Hackathon 3nd place).

All Screens View

Once Teacher clicks on the "Generate 3 hours Screen Sharing Tickets", all virtual tutors (Amazon Sumerian host) will ask student to share their screens to teacher at the same time, then teacher can view all students' screens. Teacher can send instruction to virtual tutor and it will talk to all students simultaneously. If teacher clicks on the individual student screen, it will enlarge it, and the teacher can send private message to that particular student.

This is a very important feature as now teacher can have the overview of the whole class and know which student is really working on the exercise.

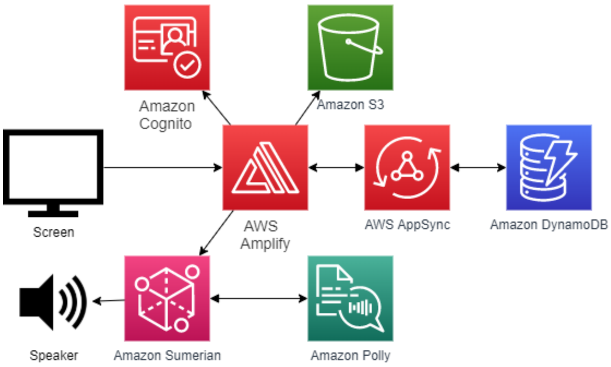

Fig. 1. Architecture of All Screens View

The reason of sending 3 hours ticket to students is this project uses Cognito User Pool with 2 user groups – teachers and students. By default, the "students" group has granted the IAM permission to upload screen capture image to Amazon S3 bucket, but it cannot limit the number or the valid upload time easily, so the system uses a ticket to control when students can share screen. Further more, with this ticketing mechanism, teachers can know which student is late for their online class as he will not have the ticket to share screen for his attendance. To save the cost, it just keeps the latest screen capture image per student. It uses AWS AppSync to connect all teachers and students together in real-time and the communication between Amplify React Apps and Sumerian Host is just using "window.postMessage". Logic are moved to React but not the state machine of Sumerian host, which is the main difference from Lab Monitor, and we can do version control easily. Once Sumerian host receives the message, Amazon Polly generates the speech for the host.

Virtual Tutor Multi-Language Subject Specific Question and Answer

Teachers don't need to write a line of code or know anything about AI, they just need to upload their lecture notes to Amazon S3 bucket and create an index in Amazon Kendra - Highly accurate enterprise search service powered by machine learning, then Virtual Tutor can answer subject related question from all students with the brain from Amazon Kendra.

For students, they can ask English question to the Virtual Tutor with Mic. If they want to ask non-English question, students can type in the question and click "Ask" button.

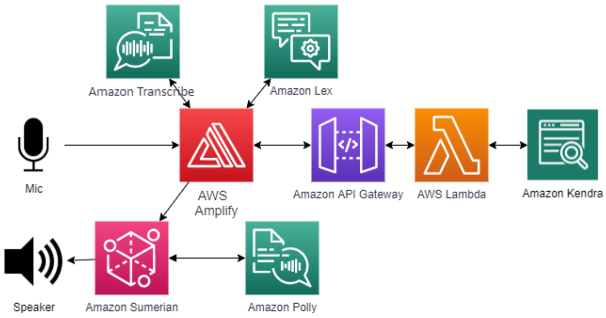

Fig. 2. Architecture of Subject Specific Q&A with Voice Input

For voice input, when student holds the mic icon, Amplify React Apps calls getUserMedia API to get the voice stream. Amazon Transcribe converts voice stream into text message, and text message send to Amazon Lex Chatbot. if Intent name is empty when the question can match defined intent and return from error handling, it means that is not a chit chat. We know student is asking a subject related question. If teacher sets the Amazon Kendra Index for his class, the question sends to API gateway REST API based by AWS Lambda. It checks the answer from the Amazon Kendra Index which indexed the notes of this subject and response the answer to Amplify React. At this moment, AWS JavaScript client SDK does not support querying Amazon Kendra directly, so we have to add a REST API to proxy the query. Sumerian host receives the answer from "window.postMessage", it converts the text to speech with Amazon Polly.

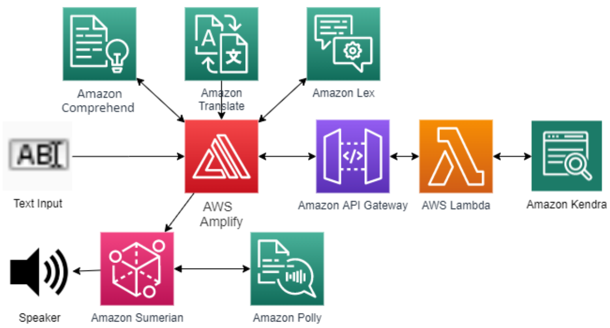

Fig. 3. Architecture of Subject Specific Q&A with Text Input

For text input, the flow is similar to the voice input flow but the question from student first sends to Amazon Comprehend which detects the dominant language of student question, and translate it into English with Amazon Translate. The English text message sends to Amazon Lex Chatbot and response message shares the same flow as voice input.

Virtual Tutor Chit Chat

Student talks anything with Virtual Tutor and she will show difference gestures based on her answer. Students

likes to play game and have fun, so a bit of gamification element is good for any class.

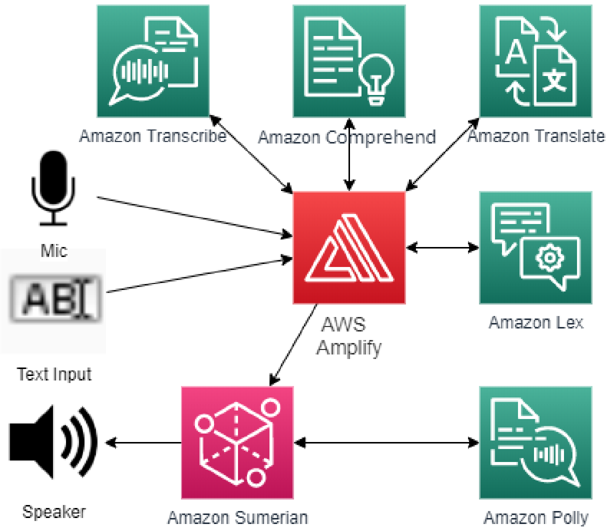

Fig. 4. Architecture of Virtual Tutor Chit Chat

This feature shares the voice input and text input flow from previous section. The difference is that Amazon Lex Chatbot will return an Intent Name and a response message. Actually, we added 86 common Intents for small talk, so this Amazon Lex Chatbot can do a chit chat. The response message will send to Amazon Comprehend for sentiment. According to the sentiment, Sumerian host will show different gesture. If the question is not in English, the response message translates back to the question's language with Amazon Translate and display the answer in English and the question's language. The English response message send to Sumerian host, and the host specks out the answer with Amazon Polly.

Work alone mode

For some cases, we have to do an online quiz or test. Capturing student's screen is not enough as they might find someone and work together i.e. classmates or bother. Therefore, All Screens support Webcam Face detection.

For the reason of privacy, we do not upload the student image to AWS and the face detection done inside student's browser.

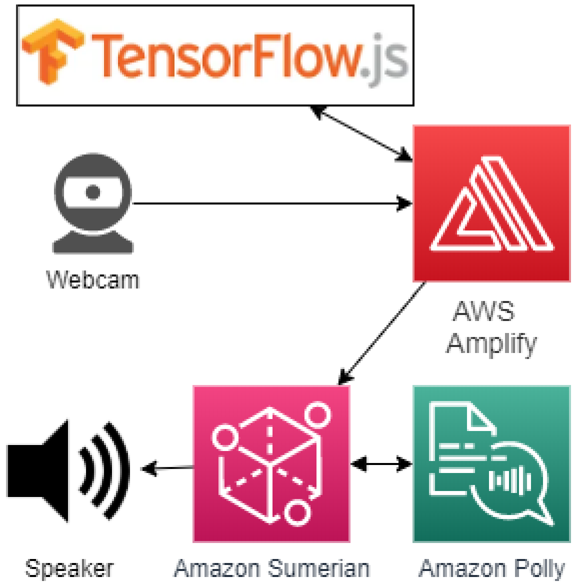

Fig. 5. Architecture of Work alone mode

For Face Detection, it captures webcam image every second. We use face-api.js which provides face detection API and Machine Learning model for TensorFlow.js. After the face detection, face highlighted image sends to Sumerian and it displays in the projector of virtual lab. When there is more than one face, React sends a warning message send to Sumerian host, and the host specks out the answer with Amazon Polly.

Conclusions

The online classes are under control by the teacher with All Screens. In fact, a lot of schools are also doing the online test or exam and it just tests student's friendship or the ability of team work but not on the knowledge of that subject. If you enable Amazon S3 versioning, you can even record how student complete their works and it gets rid of the online class cheating problem. Also, Virtual Tutor makes fun for the class with more interaction. Students can ask question anytime and anywhere.

Without All Screens, teachers never know students really learn something or not. With All Screens, teachers can know which student is really working on exercise at home or doing nothing.

What Should We Teach in the Engineering Ethics Education?

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Abstract

This paper focuses on what to teach in engineering ethics education. Students take a course in engineering ethics in the faculty of engineering at the university and National Institute of Technology. Imported from the U.S. at the end of the 20th century, the engineering ethics in Japan treats such subjects as responsibility as a profession, product liability, law and morals, compliance and whistleblowing, and safety. Teachers cannot afford to give lectures on the whole subject not systematized in a limited time. We need therefore examine the contents of the engineering ethics we educate. We make two steps to attain the purpose. First, we overview the development of engineering ethics in Japan and extract its essence. Not only engineers but also researchers in philosophy have undertaken engineering ethics education. A philosopher Saito Norifumi, for example, emphasizes that engineers should be conscious of the complexity of social accidents through artificial products, and he sheds light on the engineering technique which enables them to find the best solution with a variety of trade-off conditions considered. Criticizing and developing this argument is helpful to get some viewpoints for struggling with a case study of engineering ethics. Second, we explore the possibility of introducing a meta-ethics viewpoint to engineering ethics. It is sometimes difficult to show students how engineers behave when they face a moral dilemma because the solution found in the classroom is always "depending on the case." Engineering ethics should guide engineers to good behaviour when they hesitate a decision. Thanks to meta-ethics which asks for the good itself, students can discuss goodness for engineers, which helps them take a policy to break out the dilemma. From these approaches, we conclude with a proposal that students acquire a custom and method to question a good for engineers in every case study in engineering ethics education.

Keywords: *history, philosophy, business, profession, meta-ethics*

Introduction

Our purpose in this article is to find out what we should teach in engineering ethics. As technology develops, our social problems get more complex to resolve. According to Saito (2005; 23-27), the ethics taught in elementary and junior high school are not always valid in matters related to artificials and product liability because of its specific notion of responsibility. Educating engineers to have morale in dealing with the issues is necessary.

National Institute of Technology (KOSEN) in Japan gives engineering ethics courses in the advanced class or the 7th year of its curriculum. KOSEN has a Model Core Curriculum defined as the basic guideline for constructing a curriculum with outstanding features (KOSEN, 2017: 51-52). The contents of engineering ethics are defined as below: information ethics, environmental ethics, the contribution to the international and regional society, the intellectual property, the compliance, the history of engineering, and the sustainability. It may not be difficult to enumerate the subjects appropriate to the engineering ethics education. But it is a complicated question to discern and arrange the contents we should teach in the course of engineering ethics given 15 times in one semester.

Kobayashi (2007) indicates that KOSEN needs a program for engineering ethics education to improve students' ability to analyze and judge ethical issues, as well as to learn the relation between technology and society, the understanding of the social system, and ethics itself. Souma (2018) suggests that establishing the engineering ethics program in higher education institutions is a reaction to the introduction of an accreditation system by the Japan Accreditation Board for Engineering Education (JABEE) established without any spontaneous motivation from the institutions. Both of them emphasize that engineering ethics education has been very confusing.

We face difficulty identifying what we should teach in engineering ethics education. We try to straighten it out by dealing with two topics: Japan's history of engineering ethics education and the nature of engineering ethics from a philosophical viewpoint. And we conclude from these arguments that the professional ethics theory related to meta-ethics can be another guideline in engineering ethics education.

1. The history of engineering ethics education in Japan

Japan's history of engineering ethics education had not been a central object of academic research by the recent time when a memorable study of Natsume Kenichi appeared. He summarizes the development of Japan's engineering education chronologically, which started at the end of the 19th century (Natsume, 2021). He identified four crucial moments for a shift in history. The first was the opening of a country or the Meiji restoration. Japan introduced western cultures, engineering included, to make the country economically and militarily strong. Those who started to learn western engineering didn't have any rules or ethics as engineers. Yamakawa Kenjiro, the president of Tokyo Imperial University at that time, brought the Bushido, the way of samurai, and British gentlemanship into the engineering ethics education.

The second was the democracy movement in the Taisyo era at the beginning of the 20th century. The social status of engineers was not approved well because of their weak awareness of their social roles. The Academic Society of Civil Engineering, established in 1914, formulated a code of ethics for the first time in Japan. Based on the code from the U.S, this code has ideological characteristics of that of America. Engineers forgot the concepts and the code itself amid the Pacific War between Japan and U.S.

The third was the post-war democratization. Japanese engineers reintroduced the American engineering ethics as a new western culture. Some societies for engineers, for instance, the Japan Consulting Engineers Association, adopted their code of ethics, referring to the American Consulting Engineer.

The fourth was the globalization in the 1990s, which forced Japanese societies of engineers to establish an accreditation system to fulfill a global requirement in engineering education at the universal standard. This demand was a crucial moment in the establishment of the JABEE. However, the concept of education JABEE oriented was abstract and ambiguous, which led engineers and researchers in science, technology, philosophy, and ethics to explore the methods and contents for engineering ethics education.

We thus outlined the history of engineering ethics. Now we try to examine what we can derive from this survey. First, engineers imported the system of engineering ethics from the U.S. several times, and it has always been a rich source of the development of Japanese engineering ethics. Researchers in many fields entered the engineering ethics study in the 1990s when engineers became aware of the importance of adaptation to globalization. Due to their participation, engineering ethics has developed uniquely, especially in philosophy. It will be helpful for students in the department of engineering to know the philosophical studies on engineering ethics. Second, engineers improved the code of ethics each time they established a new organization for engineers. It is indeed necessary for engineers to make sure the way of judgment and behavior in their ordinary operations. But its effectiveness is doubtful because "it is just like a slogan, and would not play a sufficient role of guideline in an actual situation" (Iwasaki, 2000). Engineers may need an additional policy to guide themselves in a dilemma situation.

2. The development of engineering ethics by the philosopher

Researchers in philosophy have also undertaken engineering ethics education. For example, Koide (2010) and recently Kito (2018) published a textbook for students in engineering, describing ethical problems engineers tend to face. And a philosopher Saito Norifumi tried to make a system of engineering ethics. At first, he emphasizes the difference between the morals we learn in childhood and the ethics theory for engineering (Saito, 2005). At home or in school, we experience and learn about the interpersonal relationship between our parents and us, our friends and us, and the people concerned and us. But engineers must consider the influence of manufactured products on the public. Engineers, therefore, need special education in engineering ethics due to the difference between the two ethics. He set about constructing the engineering ethics system by indicating that engineers should be conscious of the complexity of social accidents related to products and sheds light on the engineer's technique which enables them to find not the perfect but the best solution under the trade-off conditions (Saito, 1998). He considers the complex system and the limited rationality as the keywords. With their finite rationality, engineers cannot elucidate all causality of this world. Even under this restriction of ability, they have to design and produce artificial products with the maximum safety and care for the public, their client, and the organization to which he belongs (Saito, 2001).

Above is one of the examples of a philosophical examination of engineering ethics. Such arguments will help students understand the concept and essence of engineering and think deeply about ethical behavior.

3. Professional ethics and meta-ethics for engineers

We go back to the question that the code of ethics is helpful for engineers in their assignments. Engineers usually belong to an organization and work under the command system and hierarchy. Engineers hardly object to orders from their directors (Okabe and Endo, 2022). In addition, one of the characteristics of Japanese engineers is a strong awareness of belonging to their organization. Natsume (2021; 20) suggests that this awareness derives from the management-familism of Japanese companies, which makes Japanese engineers give priority to a duty to their employers over an obligation to the public to which the code of ethics urges them. As is often the case with engineers, they conflict with their employers over the safety, cost, and design of a product.

For this reason, business ethics looks important in engineering ethics. In many cases, it is not engineers but the company that causes a scandal and social accident.

The nature of the company is controversial and argued in business ethics. We consider a company as a legal person who has the same right as a human, but it doesn't act like a human. This ambiguous status of a company conceals the subject responsible for an immoral action caused "by the company" (Shimura, 2011).

Students have no experience working in a company and no understanding of loyalty to a company. Through case studies, therefore, they must simulate how they should behave and judge in a moral dilemma amid a confrontation in a company. And they can access the textbook of both American and Japanese cases. Nevertheless, we have not yet resolved the problem of finding the decisive guideline for behavior and judgment when students engage in case studies.

Most of the texts written in engineering ethics emphasize that the concept of professional ethics is crucial for engineers. In some textbooks on engineering ethics (Natsume, 2021; 98. Saito, 2001; 181), the origin of professional ethics dates back to the Hippocratic oath. Ancient-Greek doctor Hippocrates declared that he would devote his life to saving people's lives as a doctor. For a doctor, the professional activity is to save lives. Then, what is a professional act for engineers? According to Aristoteles, an ancient Greek philosopher, a good architect is a person who constructs well, and a bad is who works poorly. A great engineer is a person who designs or creates well, and a bad is who plans or manufactures badly. In general, for the people who possess their specific function or operation, their goodness is inherent in fulfilling such performance. Fulfillment of the role of engineers in society is the definition of the good for engineers. What is the function of engineers? Exploring the nature of engineering will clarify it. And we know the philosophy of engineering enables us to get the knowledge of it.

Conclusions

Our concern is to know what we should teach in courses of engineering ethics education. It is a complicated question because of the richness of subjects and contents to learn in engineering ethics. We have discussed the nature of engineering, that is, a complex system under the condition of limited rationality. And it seems valid to set the good for engineers in the core or reference of our teaching policy because it is the very nature of good for engineers. We conclude a course in engineering ethics, in which students explore their guidelines of behavior and judgment based on the good for engineers through case studies, would be a satisfactory one.

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SELF-DIRECTED RESEACH (3)
THE ATTEMPT OF IMPROVING SELF-DIRECTED RESEACH BY 'ROBOT MUSUME'

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Abstract

This presentation is to introduce an example of the project of educational volunteer activities aimed for contribution to local communities as one of the themes for Self-Directed Research (hereafter SDR).

In SDR at NIT, Hachinohe College, there are several problems. First, one of the most serious problems is how to make questions or ideas. Not a few students have troubles in finding their themes, and coordinators and facilitators work on their concerns. Some of the students treat the same topics but most of students result in choosing temporary topics. Especially for third year students, the popular topics are related to their own fields in general. However, their interests are not in the application to other areas but in the basic structure. Another problem is about the structure of SDR. In SDR, it is not permitted to make a group of different grades while a pair or a group of the same grade is permitted. What is more, it is also problematic that the themes are not taken over and not deepened by the several grades of students.

To solve these questions and meet the demands of students, the 'Robot musume' project was started in 2018. 'Robot musume' is a student group consisting of female students from first year to fifth year. The group is working on volunteer activities for programming education. It is also planning to join the international educational institution called "Robogals", the headquarter of which is located in the University of Melbourne, Australia.

The main activity of 'Robot musume' is to give delivery workshops for elementary or middle school students using robots in local communities. They not only share the ideas or themes but also make original plans for teaching materials and develop better materials.

It will be made clear from the introduction of the process and the results of the series of projects that the effect of this activity is eminent in connecting students' abilities with problem solving in the regions and with the improvement of SDR.

Keywords: *Self-directed research, programming education, contribution to local communities, female students, Robogals, delivery workshop*

Introduction

At NIT, Hachinohe College (hereafter Hachinohe Kosen), one of the most appealing subjects for students is 'Self-Directed Research' (hereafter SDR). All of the students are required to work on SDR. Some students choose their own themes, make plans, conduct experiments, and examine the data by themselves. Others, roughly 10%-50% of the total students, work on the same theme in a pair or a group (of three members at most). Different from normal subjects or classes, where students generally follow teachers' guidance, introduction and explanations, it is he or she themselves that choose the theme, process, methods, observation, examination and discussion of the research. It is true that students can get advices from various people including teachers, but it is not a curriculum or obligatory. The choice of advice is totally up to each student. One of the most difficult points for the students is how to find or set the theme. Naturally, the theme of each research comes from various origins. For not a few students, the process of problem-solving is comparably easy to work on instead of problem-finding. Problem finding is deeply related to each student's ways of thinking, originality, and creativity.

Through several years' trial on SDR, the decision of theme / topic of each research has been discussed in terms of various points. One of the most conspicuous examples is to decide a 'typical' by different students year by year. For example, from the first year of SDR, many students have chosen the theme of 'sleeping' and have been conducting similar experiments and have gained similar results. There is no relation, interaction, progress in their research. In other words, they are doing their own research without referring to similar ones. It might be difficult to cultivate ideas deeply from such an individual and separate attempts on a common theme.

Pedagogy

1. What is SDR?

At NIT, Hachinohe College (hereafter Hachinohe Kosen), one of the most appealing subjects for students is 'Self-Directed Research' (hereafter SDR). All of the students are required to work on SDR. Some students choose their own themes, make plans, conduct experiments, and examine the data by themselves. Others, roughly 10%-50% of the total students, work on the same theme in a pair or a group (of three members at most). Different from normal subjects or classes, where students generally follow teachers' guidance, introduction and explanations, it is he or she themselves that choose the theme, process, methods, observation, examination and discussion of the research. It is true that students can get advices from various people including teachers, but it is not a curriculum or obligatory. The choice of advice is totally up to each student. One of the most difficult points for the students is how to find or set the theme. Naturally, the theme of each research comes from various origins. For not a few students, the process of problem-solving is comparably easy to work on instead of problem-finding. Problem finding is deeply related to each student's ways of thinking, originality, and creativity.

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2. What is RM?

Robot Musume (RM) was organized in April, 2018. The members are gathered from students of NIT, Hachinohe College, under the influence of Robogals, which is a global science and technology volunteering group. While the headquarter is placed in Melbourne, Australia, its branches are located over 31 universities in the world. They are classified in three blocks; Asia and Pacific, ENEMA (Europe, Middle East, Africa), and North America. There are two branches in Jaapan; Tokyo Institute of Technology and NIT, Kagoshima College.

The main activities of Robogals are apparently related to promoting the motivation of females students for learning science and technology and encouraging them to choose scientific careers. For the purposes, a lot of events for female students, including delivery workshops, are organized by each group in various areas. [2][3][4]

RM at NIT, Hachinohe College shares the vision and ideas with Robogals. They visit local schools and show the importance and interesting points of science and technology through their activities using robots. The main members of RM are female students from the first year to fifth year students, but male students are also welcomed. The female students can show a would-be engineer to learners, so it is possible to say that they can be a role-model for female elementary school students. [5][6]

3. The Relationship between SDR and RM

The relationship between the activities of RM and SDR is discussed here. It is obvious that there is a lot of similarity between RM and SDR as a project-based learning. First, there are no teachers / controllers (of course it is supervised by several teachers, but the content itself is totally up to students). Second, in both activities the students face audiences. They have to show what they have done or they have prepared. Third, they have to review after their workshop or presentation. In contrast to these similarities, the most largest difference is the theme choice. Generally, the themes in RM are decided while SDR forces students to choose each original one.

Especially as one of the main tasks of Robogals is the contribution to local communities, RM is working on local contribution. The most difficult and urgent problem for local school is concerning programming education, which was introduced and obligatory in 2020. As the teachers of local schools have had difficulty in IT skills, they are in need of those human resources. According the research before the activities, these problems are focused in Hachinohe and Aomori Prefecture. Several data show the introduction of programming education is far from perfect in Aomori Prefecture [7][8][9]

In order to solve this urgent problem, RM is thought to play an important role. What is more, the attempt is also meaningful as a material for SDR. Since SDR is offered to students as a step for global engineer, it shares the various goals of SDG. The activities of RM undoubtedly shares Goal 4 "Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all". F

Figure 1 Delivery workshop at local schools

4. The Possibility of RM as SDR

In this section activities of RM are shown. Since it was organized in 2018, it has been working on making the teaching material for delivery workshops at local schools (especially elementary schools). One example is the method called unplugged programming using Keystudio Smart Little Turtle Robot.
This robot have two wheels controlling line trace, microwave censor, infrared remote control, blue tooth connection. These are under control by Arduino board. [10]

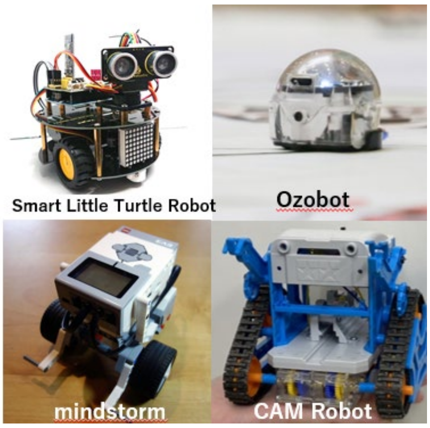

Figure 2 Robots for delivery workshops

Other examples include small robots such as Ozobot(Evollve Inc.)、CAM-robot(TAMIYA)、mindstorm(LEGO).
Let us move on to the team management of RM. Members are diverse from 1st year to 5th year, but the roles in RM are different according to the members' grade.

① 1st and 2nd year
- support as tutors in delivery workshops
- make robots
- gain techniques and skills

② 3rd year
- make plans for delivery workshops for elementary schools
- work as workshop facilitors
- help and coach juniors

③ 4th and 5th year
- make plans for delivery workshops for middle schools
- work as workshop facilitors
- help and coach juniors
- manage and organize the total activity

Thus the roles in RM are clearly separeted. Tutor means supporters to help each student or groups in workshops. To put it diffrently, RM can be regarded as a club structure. The members of RM are expected to get skills first, then make plans, and finally manage the whole activities.
As the framework of the total project is same, the plans are completely by students.

From the first year, each student start to prepare for plans for future workshops while they come to know the atmosphere of workshops. Through these processes, the single theme come to be checked, revised and improved year by year. This is made possible by the group activity.

Figure 3 Students' roles in Workshops

In four years, six groups, 11 students, make plans as themes of SDR, which is shown below.

duo	2018	Nishihakusandai Elementary School, 4th grade	
	Production of teaching materials for elementary school programming education		
	side Teacher -Smart Small Turtle Robot-		grade excellence award
	side Student -Smart Small Turtle Robot-		grade encouragement award
duo	2018	Asahigaoka Nursery School, preschooler	
	Programming for Kids		
	MakeyMakey&Scratch		
	Teaching with a Paper Play		
duo	2019	Sanjo Elementary School, 4th grade, Nishihakusandai Elementary School, 5th grade	
	Nurturing the Engineers of the Future:Toward making programming education compulsory in 2020		
	robot section		
	text section		
solo	2019	Tamonoki Elementary School, 5th grade	
	Education of programming for primary school , to 2020		grade encouragement award
duo	2020	Kamiichikawa Elementary School, 6th grade	
	Programming Class for primary school child		
	program section		
	text section		
duo	2021	Kamiichikawa Elementary School, 6th grade	
	Programming education for elementary school students		
	CAM robot section		grade excellence award
	smart small turtle robot section		grade excellence award

Table 1 The List of RM Plans as themes of SDR

It is also notable that 5 out of 11 students have received some awards.

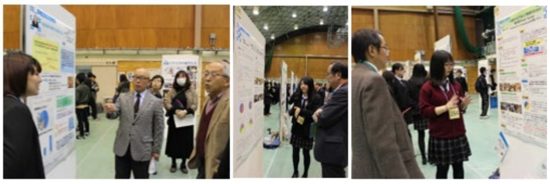

Figure 4 Presentation of SDR

Results and Discussion

The final example of RM is about the one which results in the graduation research. One female student, who graduated from NIT, Hachinohe College, in March, 2020, used to be a first leader of RM in 2018. She entered the advanced course of NIT,Hachinohe College and she chose the activity of RM as the theme of research there. She made a research on how to solve problems of introduction of programming education in local schools by the activities of RM. In local middle schools there is the subject of 'technical Art and Home economics'. In some schools, the teacher only covers the former or the latter. The graduate's research is to make RM as the material for the subject in order to solve the problem.[11][12][13]

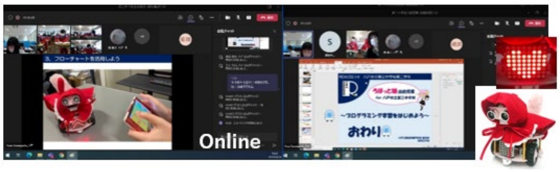

Figure 5 Delivery workshop as a special research

Her attempt has received the great positive responses but there is room for improvement in her research. Her idea was followed by her juniors. So the continuation of themes can be a great possibility for improving the idea more drastically.

Conclusion

In this paper the attempt of RM as SDR was introduced and examined. The volunteer activities of RM have been effective in solving the problems in local schools concerning programming education. It is also promising for improving theme choices in SDR. In contrast to arbitrary theme making in SDR, the continuation of themes by groups has the possibility of bettering the themes and making products such as teaching materials because of the power and cooperation of group members. Furthermore, as they face the social necessity from the first stage, the members of RM come to be more sensitive to the needs of local communities and future clients. It is confirmed from through these observations that the activities of RM are effective as a possible pattern in SDR.

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[11] Yuna TSUNAIGUCHI, Technology and Home Economics Integrated Programming Learning Robotics Materials for Improving Female Student's Learning Motivation
[12] Yuna Tsunaiguchi, Ken Sato, Yasushi Hosokawa, A Cross-Curricular Programming Learning Robotic Materials of Technology and Home Economics for Improving Learning Motivation of Female Students,NICOGRAPH 2021,pp.P12:1-P12:2
[13] https://www.art-science.org/nicograph/nico2021/ (10 July 2022)

AN INQUIRY-BASED APPROACH TO TEACHING ENGINEERING PHYSICS THROUGH DISCUSSIONS OF MISCONCEPTIONS

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Abstract

The idea of an effective learning cycle put forth by educators J. Myron Atkin and Robert Karplus (1962) has been a cornerstone of technical education. It involves three key elements: exploration, term introduction, and concept application. In this scheme, exploration allowed the learners to become interested in the subject, ask questions, and investigate the science phenomena. Introduction of new ideas and terms, by the instructor, followed. Finally, concept application provides the learners with opportunities to try out their new understandings in novel contexts, apply their new ideas in other situations, and evaluate the completeness of their understanding. We would like to suggest that a key element - the discussion of misconceptions - is missing. Studies have shown that misconceptions can impede the learning of new knowledge, are often strongly held and are highly resistant to correction through the standard modes of instruction. In addition, we would like to propose the use of an inquiry-based approach, such as the revised 5E Instruction Model (Bybee 2009), in the delivery of the discussion of misconceptions. Inquiry-based approaches have been credited for actively engaging students, incorporating cooperative learning, and deemphasizing the rote memorization of facts. The purpose of our study is to investigate whether the deliberate incorporation of a discussion of misconceptions into the instruction material and applying the 5E instructional model in a lesson delivery would produce better learning outcomes. The subject in our study is Engineering Physics. Learning of Engineering Physics has been a challenge for students because they come into physics classes with pre-conceived ideas about the subject matter that do not align with the scientific conceptions they are expected to master. Misconception-related problems were constructed using concept cartoons, video or media clips, and structured questions. The sample group consists of forty-eight students (Control Group=25; Experiment Group=23). An assessment quiz designed using two-tier questions, a student survey and a focus group discussion were used to collect data, and the data were analyzed both qualitatively and quantitatively. The findings suggested that incorporating a discussion on misconception and incorporating the 5E instructional model enabled students to achieve better learning outcomes; some misconceptions were remediated but not completely rooted out.

Keywords: *Inquiry-based approaches, revised 5E instructional model, misconceptions, concept cartoon, active learning, learning cycle*

Introduction

Teaching Engineering Physics is challenging, because teachers are not just trying to get students to learn new knowledge but are also asking them to unlearn many of their misconceptions.

Misconceptions can be described as pre-conceived ideas based on non-scientific beliefs, mixed conceptions or plain conceptual misunderstandings. These misconceptions are often seeded in a child at an early age either through their own explorations and/or learned from authoritative figures without any challenges from the knowledge acquirers and hence they become deep-rooted with time.

For example, when adults are confronted with questions from young children, rather that admitting to not knowing the answer, it is common for them to give an incorrect one. Other sources of misconceptions include cartoon programs or even teachers.

The teaching of science has been largely influenced by educators J. Myron Atkin and Robert Karplus (1962). They proposed a way to structure the teaching of science through the use of a learning cycle, which involved three key elements: exploration, term introduction, and concept application.

A learning cycle moves students through a scientific endeavour by having them first explore materials, then construct a concept through the introductions of terms, and finally apply or extend the concept to other situations.

Abraham and Renner (1986) investigated and found that these three stages of the learning cycle are in their optimal sequence. They found that when concept introduction followed exploration, students learned better. The introduction of terms after investigations helps students connect new concepts with prior

experiences. This is consistent with constructionism and experiential learning, which state that learning is construed through action.

Yet, the learning cycle does not directly address misconceptions, which is a well-known obstacle to learning the sciences.

We like to suggest that a key element - the discussion of misconceptions - is just as important, and that a deliberate incorporation of the discussion of misconceptions into instruction material will help students learn better.

We propose the delivery of this missing element using an inquiry-based approach to trigger the curiosity and students' hunger to discover the answers for themselves.

The delivery mode we selected is the BSCS 5E Instruction Model, popularised by Bybee (2009). This revised 5E Instruction Model has been credited for engaging students actively, incorporating cooperative learning, and deemphasizing the rote memorization of facts.

Our investigation centred on evaluating the effectiveness of intentionally introducing discussion of misconceptions towards improvement in students' learning and academic achievement. We will discuss the method used, our measurement and the outcome of our investigation in this paper.

Method and Materials

The BSCS 5E model consists of these cognitive stages of learning: engage, explore, explain, elaborate and evaluate (Figure 1).

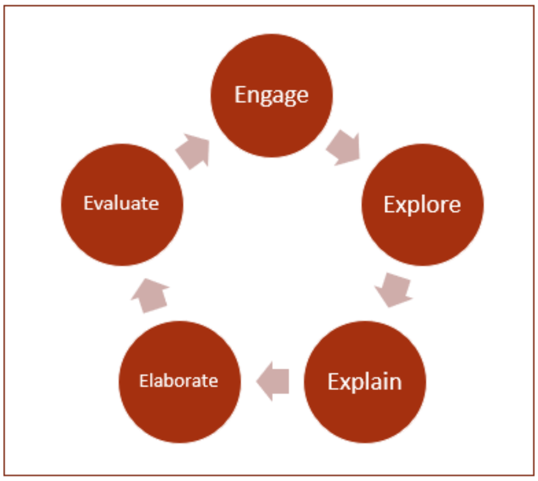

Figure 1 BSCS 5E model

In the preparation of materials and delivery design, we picked a misconception to work on for each topic. For instance, in kinematics, the relationship between velocity and acceleration is often misunderstood, and in dynamics, the identification of action and reaction pairs, and so on. For each topic, we delegate one to two lessons to the discussion of misconceptions. In the following sections, we will describe our course of action in each of the 5E stages.

Engage

In this first phase of the cycle, our goal is to provide a context that piques the students' interests by relating the content being taught to something relevant and relatable. As much as possible, that "something" is taken from experience in daily life. Different "hooks" are used for different topics. The task of the tutor in introducing the hooks is to leave unanswered questions and to build a sense of curiosity and challenge. The tutor also invokes the students' prior knowledge so that knowledge can be constructed from what students already knew. Students are then encouraged to apply process skills, such as investigating, hypothesizing, and debating to find the answers.

An example of a hook that we designed is shown in Figure 2. In this example, we want to address the misconceptions pertaining to the relationship between velocity and acceleration. Acceleration is commonly mistaken to be always in the same direction as the velocity. We made use of the tossing of a ball to set the scene for students to examine the relationship between velocity and acceleration. The tossing of a ball vertically upwards is a common experience in daily life.

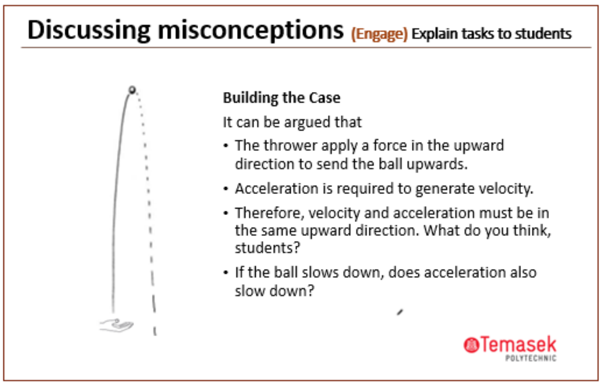

Figure 2 Sample of teaching material used in engaging

In the preparation of materials, we made use of cartoons, videos, or even structured questions as our hook. Figure 3 shows a hook that is prepared using cartoons.

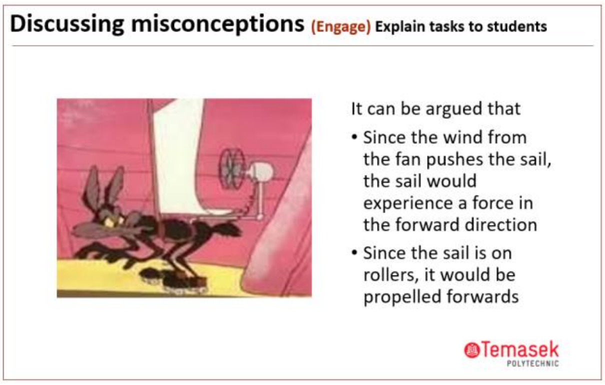

Figure 3 Sample of hook using cartoon

Explore

In this second phase of the cycle, the students form groups to investigate the hook or misconception that is assigned to them. This phase is the main inquiry-based activity, and it incorporates active learning and collaboration. Students are encouraged to work in a cooperative learning environment without direct instructions from the teacher. In some instances, students can design a simple experiment to investigate their hypotheses.

In our example of the investigation into the relationship between velocity and acceleration, a total of four hooks, one for each student group, were introduced.

The *engage* and *explore* phases can be viewed together as a problem-based learning (PBL) approach. Students are presented with a problem to trigger learning as opposed to direct presentation of facts and concepts.

When engagement takes place as a pre-assigned task, and students take the exploration of the topic on their own before the start of the next lesson, it reverses the traditional practice of introducing new content at school before assigning homework. Lo (2017) described such an implementation as a flipped classroom technique.

Explain

In this third phase of the cycle, students explain their understanding of the misconceptions. It is likely that new questions will be generated. The explanation phase is essential because students have to internalise their understanding and articulate their thoughts. In trying to explain their understanding to their classmates, students must address the other misconceptions that their classmates have. Explaining is a mind-on process that crystallizes one's thinking and reinforces one's understanding of the underlying concepts.

After the students have shared their own explanations, the tutor introduces scientific terms and technical information in a direct manner. This phase includes the clarification of any student misconceptions that may have emerged during the engagement or exploration phases and were not satisfactorily dealt with. Formal definitions and notes are also provided at this stage.

Elaborate

In this fourth phase of the cycle, students are required to link their newly acquired concepts and apply them to other applications. That is, they will need to seek out applications and day-to-day phenomena that can be explained using these concepts. The goal is to help students develop a broader and deeper sense of their newly learned concepts. Students may do further research on the internet and are required to write a short report of their findings. For some topics, students only need to attempt some structured questions that are related to applications.

Evaluate

In this fifth phase of the cycle, students are evaluated to assess their understandings and abilities, as well as their progress towards meeting the desired learning outcomes.

Evaluation is actually an on-going process in all stages and not just at the last stage of the learning cycle, even though in Figure 1, it appears diagrammatically that evaluation is only carried out only at the very end.

In the engagement stages, the tutor evaluates if the students' curiosity has been stirred. In the exploration stage, where the main inquiry-based activity is, the tutor evaluates the students by observing if they had applied the process skills to look for evidence or to test their hypotheses. In the explanation stage, the tutor evaluates the students' thought process and system of thinking. In the elaboration stage, the tutor looks out for the students' ability to apply their new knowledge to different situations through their written reports or answers to the structured questions. Finally, a summative assessment in the form of a quiz is given to evaluate the students' learning.

Mode of research

The sample in our study comprises of forty-eight students from two classes. The experiment group consists of twenty-three students from one class and the control group consists of twenty-five from another class. Students in both classes have similar abilities and scores in their previous summative assessments prior to the introduction of the teaching of misconceptions to the experiment group. This is confirmed through a quantitative analysis of the two groups.

To evaluate the effectiveness our study, we made use of both quantitative and qualitative methods.

Our quantitative evaluation is based on the summative quiz mentioned in the *Evaluate* section. The quiz consisted of two-tier multiple-choice questions. The first tier is a fact-based question, and the second tier is a reasoning-based question. The use of two-tier multiple-choice question permits higher order thinking skills to be evaluated. An example of a two-tier question that we designed is shown in Figure 3.

1. Mr. Pasan tossed a ball vertically into the air and it landed on the grass patch just in front of him. Which of the following statement is true about the ball's acceleration?

A. Its acceleration at the highest point of motion is zero.
B. Its acceleration at the highest and lowest point of motion is zero.
C. Its acceleration on the upward path is -10 m/s and downward path is +10 m/s.
D. Its acceleration on the upward and downward paths is -10 m/s.

(a)

2. Taking the starting point as the point where the ball leaves Mr. Pasan's hand, which of the following statement is true about the ball?

A. Its displacement and acceleration are always in the opposite direction throughout the entire motion.
B. Its displacement, velocity and acceleration are all in the same direction when the ball has fallen past the starting point.
C. Its velocity and acceleration are always in the opposite directions.
D. Its velocity and displacement are always in the opposite direction when the ball is falling.

(b)

Figure 3 Sample of two-tier question used (a) tier 1 (b) tier 2

The qualitative method we used comprised of a survey and a focus group. The sample investigated was the experiment group of 23 students.

The survey comprises a list of dichotomous questions and open-ended questions. These questions aim to collect the students' perspectives of these lessons on misconceptions.

A group of seven students were selected for the focus group interview. The purpose of the focus group was to clarify some of the responses to the suvey, particularly the responses to the dichotomous questions to get a better insight into the dynamics that took place during the lessons. Table 1 shows a sample of the questions asked during the focus group.

Table 1 Samples of focus group questions

1	Provide some suggestions on how to improve the learning material.
2	How do we encourage students to speak up more freely during the explain stage?
3	Do you feel that the environment was safe enough for you to express your thoughts and make mistakes?
4	In what way could the facilitator increase the level of participation in the exploring stage?

Results and Discussion

Prior to the introduction of misconceptions, the two selected groups were analysed in terms of their mean scores of a summative assessment to ascertain that they have comparable abilities in Engineering Physics. We want to increase the likelihood that when misconceptions are introduced into the class, any significant improvement in the student outcome is due to the introduction of the misconception itself.

We conducted a two-sample F-test and a two-sample t-test on the scores of the summative assessment.

The null hypothesis for the F-test is that the variances of the two groups are the same and the alternative hypothesis is that the variances are not equal at the 5% level of significance. The analysis was performed using Microsoft Excel, as shown in Table 2. The p-value needs to be doubled, since Excel only performs a one-tailed test, and that yields a p-value of 0.42, which is greater than the alpha value of 0.05. The test shows that there is no significant difference in the variances of the two groups with 95% confidence.

Table 2 F-test on the 2 samples

	Control	*Experiment*
Mean	3.88	3.65
Variance	1.11	0.78
Observations	25.00	23.00
df	24.00	22.00
F	1.42	
P(F<=f) one-tail	0.21	
F Critical one-tail	2.03	

In the case of the two-sample t-test, the null hypothesis is that the mean scores of the two groups are the same and the alternative hypothesis is that the mean scores are not equal at the 5% level of significance. Again, the analysis was performed using Microsoft Excel and is shown in Table 3. The t statistic of 0.81 is less than the critical value of 2.01. Hence, we do not reject the null hypothesis.

Together, these analyses tell us that the mean scores of our selected groups are not significantly different and the variability of each group is the same.

Table 3 t-test on the 2 samples

	Control	*Experiment*
Mean	3.88	3.65
Variance	1.11	0.78
Observations	25.00	23.00
Pooled Variance	0.95	
Hypothesized Mean Difference	0.00	
df	46.00	
t Stat	0.81	
P(T<=t) one-tail	0.21	
t Critical one-tail	1.68	
P(T<=t) two-tail	0.42	
t Critical two-tail	2.01	

Next, we use the two-sample t-test again to investigate if the deliberate discussion of misconceptions using the BSCS 5E model is effective in

clarifying misconceptions. The data was on based on a summative assessment that was carried out after the introduction of such lessons. The null hypothesis is that the mean scores of both the experiment and control groups are the same. The alternate hypothesis is that the mean score of the experiment group is higher than that of the control group. The level of significance is selected at 5%. The data is analysed using Microsoft Excel and our results are shown in Table 4.

Table 4 Result of two-sample t-Test (assuming equal variances)

	Experiment	*Control*
Mean	2.22	1.36
Variance	1.72	0.91
Observations	23.00	25.00
Pooled Variance	1.30	
Hypothesized Mean Difference	0.00	
df	46.00	
t Stat	2.61	
P(T<=t) one-tail	0.01	
t Critical one-tail	1.68	
P(T<=t) two-tail	0.01	
t Critical two-tail	2.01	

	Experiment	*Control*
Mean	2.22	1.36
Variance	1.72	0.91
Observations	23.00	25.00
Pooled Variance	1.30	
Hypothesized Mean Difference	0.00	
df	46.00	
t Stat	2.61	
P(T<=t) one-tail	0.01	
t Critical one-tail	1.68	
P(T<=t) two-tail	0.01	
t Critical two-tail	2.01	

The analysis shows that the mean score of the experiment group is greater than that of the control group with 95% confidence, since the t statistic of 2.61 is greater than the critical value of 1.68.

From our qualitative survey, we found that 84.2% of the students could discover their misconceptions through this mode of instruction and that 89.5% of them agreed this mode of instruction helps them to understand their concepts.

The outcome of all dichotomous questions of our survey is summarised in Table 5. Active learning took place, as evident in questions 1,2, 7 and 8. Collaborative learning was demonstrated, based on the outcomes of questions 4,5 and 6. Relating to real-life situations and getting feedback from the tutor help students are better ways of reinforcing their concepts, as pointed out in questions 9 and 10.

We also included open-ended questions in the survey, as well as a focus group discussion, and found the following:

1. To the question on what the students like most about the exploration stage, the common responses given are seeking "clarification" from teammates, "talking and discussing with friends", and "exploring" different answers on their own. The common responses to what they dislike most about exploring is dealing with the "uncertainties".
2. To the question on what the students like most about the explaining stage, the common responses given are "sharing" and "helping others understand". What the students dislike most about the explaining stage is giving an incorrect answer and not able to understand the misconceptions of their fellow classmates.
3. While no questions were asked about the elaboration and evaluation stages in the survey, they were asked in the focus group discussion. Generally, students found the feedback from the tutor useful in their learning and being about to apply their concepts to new situation and real-life application reinforces their understanding.

Table 5 Summary of dichotomous questions in survey

Q.N.	Questions Asked	Agree	Disagree
1	Exploring the solutions with my groups mates helped me to think about the problem from multiple dimensions.	84.2%	15.8%
2	The explore stage helped me to think about the solutions actively.	78.9%	21.1%
3	By exploring the solutions with my group mates, I felt we could learn from one another.	89.5%	10.5%
4	We were able to build on one another's solutions or ideas in our discussion.	89.5%	10.5%
5	I enjoyed the discussion about the problems and solutions with my group mates.	89.5%	10.5%
6	Explaining our solutions to our other classmates help us to think about what our classmates might have misunderstood.	100.0%	0.0%
7	Explaining our solutions to our other classmates made us want to know if they understood us or not	89.5%	10.5%
8	I find trying to explain to our classmate satisfying.	78.9%	21.1%
9	Relating the problem to a real life situation reinforces my understanding of the concept (the Elaborate stage)	89.5%	10.5%
10	Feedback from tutor help me to reinforce my concept.	100.0%	0.0%
11	Overall, I could discover my misconceptions through this method.	84.2%	15.8%
12	Overall, this method helps me to understand the concepts	89.5%	10.5%

As the focus group discussion centres on how to improve the delivery of the lesson, the data and results of the focus group discussion is not discussed here.

Conclusions

A study into the use of the BSCS 5E model mode of instruction for the discussion of misconceptions in the teaching of Engineering Physics was conducted.

Two groups, from two classes, with similar mean scores and variances were selected for the study. The experiment group has 23 students and the control group has 25 students.

The introduction of misconceptions in lessons using the BSCS 5E model is effective in improving student's learning outcome. The mean score of students in the experiment group was found to be higher than that from the control group with 95% confidence.

84.2% of the students surveyed agree that they could discover their misconceptions through this mode of instruction and that 89.5% of them agreed this mode of instruction helps them to understand their concepts.

In general, students benefitted from the BSCS 5E delivery mode. Active learning was achieved, and collaborative learning was demonstrated. Relating to real-life situations and getting feedback from tutor help students is a better method of reinforcing their concepts.

Feedback from students showed that while they are uncomfortable dealing with uncertainties, they enjoyed exploring and discussing solutions and ideas with their friends.

Overall, the introduction of discussion of misconception using the BSCS 5E model was able to improve student learning outcome in Engineering Physics but did not root out misconceptions completely.

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IMPLEMENTATION OF SELF-DIRECTED LEARNING IN BUILT ENVIRONMENT WITH LEARNING MANAGEMENT SYSTEM

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Abstract

Self-directed learning, in short SDL is an important 21st century skill in this constantly changing demands of globalization and especially in challenging times like this, COVID 19 pandemic.

Self-directed learning is not just about asking learners to learn themselves but it involves a whole spectrum of self-directed learners' characteristics (Gibbons, 2002) of 3-stages of learning skillsets: Ownership, self-managing & self-monitoring and extension of learning. It is also not just an add-on opportunity to a learning activity such as a research task to work on their own. Rather, it needs to be deliberately built into the curriculum with technology to support and enhance the self-regulated learning skills.

This paper briefly describes the holistic approach to infuse self-directedness elements into six(6) diplomas in the School of Architecture and the Built Environment (ABE). The holistic approach aims to instil SDL habits into learners through the adoption of a self-regulated learning diagnostic tool. It evaluates and determines students' readiness in the SDL spectrum and highlight to educators SDL intervention measures. The use of technology to support the approach is also examined to provide opportunities for students to self-manage and self-monitor throughout the process of self-directed learning. In the process, students developed skills to manage, review and evaluate their learning.

This paper focuses on exploring how technology, in this case, features in a learning management system (LMS) - discussion and assignment tools to support or enhance the nurturing process of self-directed learning. It also discusses the benefits of using LMS for teaching staff to trace individual learning and team's communication as well as their progressive work done outside the classroom. It then presents summaries of qualitative students' feedback as well as learning reflection traced and discussed.

Keywords: *Self-directed, self-regulating, holistic, Learning Management System, intervention, behavioural.*

Background

ABE-Teaching and Learning Unit was first formed in Oct 2018 with 3 academic mentors. Self-directed learning (SDL) was our first Innovation in Teaching & Learning project initiated in November 2018 and sponsored by ABE-director. To engage the teaching community to co-create with us, 3 champgroups were formed in September 2019 to effectively integrate SDL elements into the current curriculum and they are:

1. **Evaluation champgroup** contributing to SDL evaluation and intervention programs.

2. **ECG champgroup** contributing to integrating SDL foundation knowledge, skills and attitude into ECG1 curriculum in a semi-structured learning space.

3. **FYP-Internship champgroup** contributing to SDL in action through integrated project and internship module in a structured learning space.

We believe that we have SDL elements already integrated in our current teaching practices and nurturing SDL is a process and a journey for both students and lecturers. Each champgroup in the SDL journey aims to strengthen these practices and journey, the use of learning management system (LMS) is the common means in each champgroup's work intended to support and provide opportunities for students to self-manage and self-monitor throughout the process of self-directed learning. In the process, students developed skills to manage, review and evaluate their learning.

This paper represents the main author's first iteration of an action research in using LMS to foster SDL and later contributing to the SDL holistic implementation approach in ABE.

Introduction

Integrating skills and values into curriculum (The CDIO Approach) has been my teaching belief system since 2010. Some of the challenges I encountered were:

1) Intermittent checkpoints to track students' thinking thoughts not sufficient or effective to foster SDL.
2) Not able to trace team's communication and progressive work outside the classroom
3) No concrete evidence to resonate with self & peer assessment result.

A Self-directed Learning Model

Singapore Polytechnic SDL framework (2018) as depicted in Figure 1, has been introduced to teaching staff to explain the processes that underpin SDL. It provides a 4-stages of learning skillsets: plan, manage, review & evaluate and extend learning, regulated by the use of metacognition and activated with growth mindset and intrinsic motivation to complement the learning skillsets.

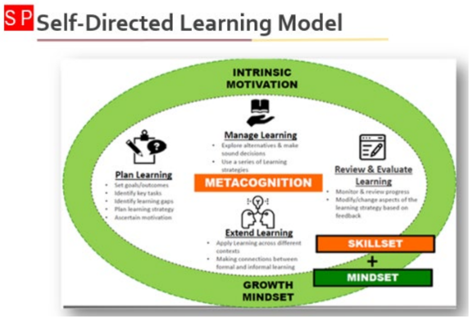

Figure 1. SP SDL Framework (2018)

In order to be relevant to teaching staff for facilitation and assessment, enabling elements in the SDL were further identified and synthesized. The term, SDL has been used inevitably synonymously by many researchers with self-regulated learning (SRL). Knowles (1975) defined self-regulated learning (SRL) as a process, "... in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes". Drawing on Singapore Polytechnic SDL model (2018) and SRL definition, it is clearly seen that SRL is a subset of SDL. This distinction is made and discussed in several places (Zimmerman, 2014 , Jossberger et al, 2010 and Schunk, 2008). In other words, SDL encompasses SRL which according to Luca & Mcmahon (2001) is viewed as the intersection of cognitive and affective domain that formed the conceptual framework assessing self-regulatory skills. The authors listed the attributes that characterized SRL in each domain.

Figure 2a represents the ABE SDL model, synthesized and adapted from the above discussion and framework. It is underpinned by SP SDL and Gibbons' model, driven by SRL (Luca & Mcmahon, 2001) activated with growth mindset and intrinsic motivation. Growth mindset, metacognition and influencing behavioral is selected as the primary enabling elements in this model.

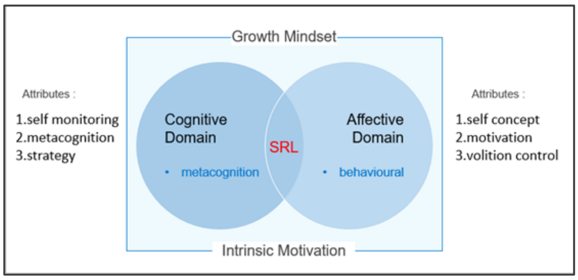

Figure 2a. ABE SDL model

A SDL Diagnostic Tool

Learning and Study Strategies Inventory (LASSI) developed by Weinstein, Palmer & Schutle (1987) based on 77 statements related to learning and studying. This is revised by Luca & Mcmahon (2001), who have studied and carefully reducing to 24 statements that are integral to the concept of SRL - the 6 attributes (self-concept, motivation, volition control, self-monitoring, motivation and strategy formation) in the 2 SRL domains (Figure 2a), 4 statements to each attributes and 3 statements to Growth mindset which is added in by champgroup to complete the diagnostic list, as shown in Table 1. It gathers information about learning and study practices and attitudes related to learning and studying. These statements were deployed and administered through an online survey, data collected and analyzed with an algorithm improved by the Evaluation champgroup to measure students' mindset, attitude and how they use learning strategies in academic environments so that they can be strengthen through intervention.

Table 1 SDL diagnostic evaluation statements

Cognitive	Affective
Self-Monitoring: 1. I am up-to-date in my class assignments 2. I compare class notes with other students to make sure my notes are complete 3. I review my notes before the next class 4. I test myself to be sure I know the material I have been studying	**Self-Concept :** 1. I worry that I will flunk out of school 2. When I begin an examination, I feel pretty confident that I will do well * 3. Worrying about doing poorly interferes with my concentration on tests 4. I get so nervous and confused when taking an examination that I fail to answer questions to the best of my ability
Metacognition : 1. I try to see how what I am studying would apply to my everyday living 2. I try to find relationships between what I am learning and what I already know 3. I try to relate what I am studying to my own experiences 4. I try to interrelate themes in what I am studying	**Motivation :** 1. I would rather not be in school 2. I only study the subjects I like 3. When work is difficult I either give up or study only the easy parts 4. I tend to spend so much time with friends that my coursework suffers
Strategy Formation : 1. I make drawings or sketches to help me understand what I am studying 2. I learn new words or ideas by visualizing a situation in which they occur 3. I translate what I am studying into my own words 4. When I study, I have trouble figuring out just what to do to learn the material *	**Volition Control Strategies :** 1. Even when study materials are dull and uninteresting, I manage to keep working until I finish 2. When it comes to studying, procrastination is a problem for me * 3. When I decide to study, I set aside a specific length of time and stick to it 4. I concentrate fully when studying
Growth Mindset : 1. I can learn new things, but I don't have the ability to change my basic intelligence. 2. My intelligence is something about me that I personally can't change very much. 3. I have a certain amount of intelligence and I really can't do much to change it.	

Fostering Self-directed Learning

In direct translation self-directed learning (SDL) means to study yourself. To be a self-directed learner and to nurture a self-directed learner need more than just study yourself. It need a process of self-reflection and learning strategies. In order to help students to gain self-regulated learning skills, there is a need to provide lecturers with teaching and learning skills having students to practice SDL in the context of learning tasks.

Key Tasks for Students

The success of SDL partly lies in the responsibility of students to apply the learning skillsets in their SDL journey. This point is discussed in many places and advocated by many education researchers (Luca & Mcmahon, 2001; Zimmerman, 2014; Tan & Ling, 2015). It is therefore important for students to know what to do in order to be a self-directed learner. They have to be responsible to accomplish these 3 main key tasks at all times as shown below and depicted in Figure 2b:

1. plan their own learning and take ownership;
2. manage and evaluate learning and
3. learn how to extend their learning in a different context to create new learning.

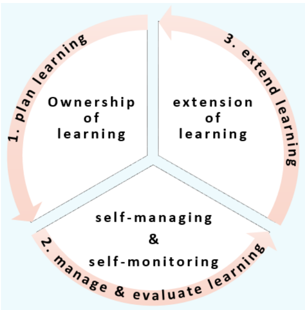

Figure 2b. SDL Key Tasks

Teaching SDL in a Project-based Learning (PBL) Approach

There are many ways to implement SRL in a classroom but Elsa et al. (2019) in their reviews of SDL models, found that face-to-face instruction was still the predominant mode of delivery. The role of the educator as facilitator of learning is therefore essential to fostering SDL. The success of SDL, therefore partly lies in the teachers' belief, mindset and knowledge on SDL intervention measures and facilitation skills.

The approach to teach students to be self-directed is to help them find it within themselves by activating the primary enabling elements in the ABE SDL model: Growth mindset, metacognition and influencing behavioral. Metacognition and behavioral change are the focus of this paper. Research has shown '…behavior is habitual and to cause behavioral change, you need to combine at least 4 sources of influence, the chances of success will go up by more than 10 times!' (Patterson et al., 2007). Table 2 shows the 4 insightful strategies for influencing behavior change by Hyrum (2011) and the related to our context interventions measure lecturers can adopt in their domain-specific knowledge teaching to foster SDL.

Other teaching strategies strongly recommended by Zimmerman (2002) in improving metacognition in the specific-domain area are:

1. encourage students to establish specific goals for their academic work or teach explicit study strategies
2. Give students choices regarding methods for carrying out complex assignments.

Create opportunities to allow students to think about their learning via journaling, self-evaluate their work, self & peer assessment in teamwork. These are tasks involving reflective thinking that often surface mistakes, challenges and helps to create space for growth, independence and responsibility for learning.

Table 2 Strategies of Influence

s/n	*4 strategies of influence*	*Intervention Measure*
1	Change the Environment	Change of teaching style by integrating active learning into the classroom such as flipped classroom, collaborative learning (project based learning and team based learning)
2	Personal Motivation	Changing content slides to interactive learning e-material, adopting engaging class activities
3	Deliberate practice	Scaffold the learning through deliberate practice. It is not just about repeated practice but each time the practice is repeated with an aim to a deeper or new understanding on the same task.
4	Peer influence	Orchestrating good peer influence in the classroom and eliminate randomized grouping.

LMS to Support Metacognition And Behavioural Change

The use of information & communication technology (ICT) to support SDL is intended to provide opportunities for students to practice SDL (behavioral such as self-manage and self-monitor throughout the process of self-directed learning) in the context of learning tasks (metacognition). In the process, students developed skills to manage, review and evaluate their learning.

Two education environment scenario of learning tasks are described as follows, organized according to fostering SDL with students key tasks.

Scenario 1 : Journaling in LMS

I wanted to build students' SDL foundation by exposing them to the SDL 3 key tasks in their year 1, ECG module via journaling. Focus on journaling is not about aiming towards perfection but it's about making progress on the journey of learning. Regular entries in the learning journal aim to force the focus of reflection on to the self and personal action aligning to SDL attributes in Figure 2b. In the process, facilitated deliberate practice will make students see it as an impetus to change and growth. Journal tool in LMS is adopted as the platform for students to create a private personal learning journal with

their personal tutor. In this platform, it allows students to upload their goals setting and personal action plan task in ECG1 module and to create a learning conversation with their tutor. A module named as ‘PTN connect’ was set up in LMS to facilitate students’ 3 years SDL journey with different tutor in each year.

Personal tutors can facilitate the process by giving online feedback leading them to make improvements as well as using assessment rubrics to focus student attention on goal setting and planning. A rubrics set up in LMS shown in Table 3 suggested for assessing setting personal mission statement or as goal setting after a series of self-discovery activities on strengths, weaknesses and core values (a coursework set in ECG1 module). Such kinds of processes can be reinforced and followed up in the other modules in the later part of students’ journey as described in scenario 2.

Table 3 Suggested Rubrics set up in LMS

Criteria	Levels of Achievement			
	Novice (15 points)	Competent (25 points)	Proficient (35 points)	Exemplary (50 points)
Goal setting	Needed substantial help to set a personal goal	Set a goal focus on personal gain	Set a personal goal in consideration of his/her strength and weakness	Set a personal goal in consideration of his/her strength and weakness and with core values
Planning	Plan has missing steps, and the process didn't follow the plan	Some of the steps in the plan weren't clear or actionable	Design a plan that was feasible and realistic to follow	Use skills, and priorities to thoughtfully and accurately build a practical yet flexible plan

Scenario 2 : Supporting Project Based Learning (PBL) with LMS

This scenario is a continuation from scenario 1, a redesign in context for SDL opportunities to take place via PBL. With their prior knowledge or experience in SDL foundation, the 3 SDL key tasks, it is now the responsibility of lecturer to integrate SDL elements into the specific- domain knowledge context. This will bring students to the next level of SDL skills.

This scenario takes us to a year 3, 6 weeks real-life project in the module Precast Concrete Technology. In order to create good peer influence, groupings are carefully selected with students of varying GPA. It is assumed and believed that students with higher GPA are self-directed and if not they are more intuitive to new teaching and learning methods. A clear signal is sent to students that this is not just another group project but a project with redesigned tasks which uses group learning and SDL as its skill-development vehicle with the following considerations:

- Provide an online platform for them to communicate with team members and for progressive work submission creating self-managing and self-monitoring opportunities.
  - This give students the opportunities to emphasise the SDL skills as they direct their learning as a team aiming to complete the project tasks.

- Provision of project tasks to develop multiple perspectives and reach a common consensus for the project task.
  - This aims to make student think how to apply what they have learnt into the project with lecturer’s feedback and facilitation through their submission of progressive work done by the team.

This involves the use of LMS Group tool to create groups of students for students in the same group to interact with each other and demonstrate their knowledge while learning strategies were explicitly taught through the project tasks. Brown, Bull and Pendlebury (1997) advocated the reflective practice assignments ‘measure capacity to analyse and evaluate experience in the light of theories and research evidence’. This is also what I want to achieve by requiring project teams to keep group learning journal in their project journey.

LMS has also provided with many tools of collaboration. The section below show how I used two of the tools: Group tools and Group Assignment to track and trace teams’ communication and progressive work as well as using these tools to feedback and facilitate their learning.

1) Group Journal tool

   Group Journal tool tracks teams’ communications and allows students in the same team to upload their progressive work done as well as for lecturers to provide feedback.

   I am able to see the collaborative discussion in the team via the comments tab and their progressive work done with attachment as well as my comments and feedback for the team. On the right panel is a record list of their submissions and finally the grading at the end of their project. With this records of progress work and their communication, I am more confident and with ease to do a fairer assessment of their peer assessment.

2) Group Assignment and Group Discussion tools

   Knowing that D2L our new LMS does not have Journal tool, I started explore other LMS tools that are also available in D2L to replace Group Journal. I found that Group discussion coupled with Group Assignments can be used to replace Journal. The workaround is to use Group Assignment (with multiple attempts of submission) coupled with Group Discussion which I found to be a more structured way of getting the team to discuss and promote collaboration.

Group Assignment
Group assignment can be set up to accept group submission. Only one member of the team submits the team's collaborative work on behalf of all of the members. Lecturer then give feedback and grade the one collaborative work submission and the grade is distributed to all members of the group automatically. Lecturer has the option to change any individual members' grade if necessary. This lead to better project facilitation to scaffold students' learning.

Feedback and grading are assigned automatically and visible to all other members in the same team. This cuts down lecturer's workload of entering the individual member's mark to their self-maintained mark sheet which is listed not in order of their grouping but according to students' admission number.

Group assignment grade is set visible to students as "complete/incomplete" even there were marks. The marks given was to reflect on the amount of work done as in their project specification while I focus on facilitating the quality of their work done submitted aim to deliver the 2 considerations listed in scenario 2 earlier.

Group Discussion
To further trace the team communication outside the classroom, a discussion Board is used that allows them to share thoughts and ideas about the project. To create thoughtful discussion, it is purposefully made as a requirement in the project that they create Thread in the Discussion Board for a specific task in the project, example as below:

a) Establish your team thread
On a weekly basis, students create a post to document their work done progress. This activity builds
students' discipline and enabling them to manage and monitoring their learning.

b) Design thread
This allows team to share their thoughts and ideas about the design task coupled with facilitated learning with lecturer's weekly feedback at the Group Assignment.

c) 3D Modelling thread
This allows team to manage their work-in progress 3D digital model and speed reviews and approvals from the team

Feedback and Discussion

A survey was conducted at the end of the scenario 2 learning experience to gauge the effectiveness and relevancy of how the learning journey (refer to the 2 scenarios above) can be redesigned to provide opportunities for SDL to take place. Students were asked to respond to questionnaires with rating of 1(totally not true) to 5(totally very true): Quantitative responses to rate their experience in shaping them to be a more responsible and independent learner as well as on their learning experience at the end of scenario 2 were collated from 2019 to 2021 and tabulated in Table 4. A constant percentage of 75% (average) responses on questionnaire a) & b) were positive. This implied that they do recognise that their learning experience will lead them to become a SDL. An additional question was asked for the latest batch of 53 responses to rate their experiences on opportunities to connect the knowledge they have learnt and applied it in the project. A 79% of responses were positive and this is supported by students' learning reflection which has reflected how they have benefited from the project based learning. Learning reflections of a few students in 3 different learning abilities were further collated and tabulated in Table 5. For average and especially the already doing well students, they will do well with any methods of delivery. I am particularly interested in weaker and less motivated students' learning reflection who find updating their project reflective learning journey online a chore. However, I am glad that their feedback were positive and encouraging (Table 5, case 1). These reflections, together with the high positive percentage rating have indicated that students recognized lecturer's effort in nurturing them to be a self-directed learner.

Table 4. Percentage of Quantitative Responses >= rating 4
[**Rating Scale:**1=**Not** True to 3=**somewhat True** to 5=**Very True**)]

Derived Questionnaire	AY19-20 (25 responses)	AY20-21 (21 responses)	AY21-22 (53 responses)
Using Technology – LMS			
a) in shaping you to be a more independent and responsible learner	72%	73%	74%
b) in helping me to be more aware of my learning progress and thus improves my learning	76%	74%	74%
c) has given me opportunities to connect the knowledge I have learnt and applied it in my project	-	-	79%

Conclusion

Often we tend to miss teaching explicit learning strategies for abstract concepts like SDL. The success of SDL partly lies in the lecturers' belief, mindset and knowledge on SDL intervention measures and facilitation skills. In another words, the lecturer's role is crucial in the design process of the lesson to integrate SRL strategies into the lesson. On the part of students, initially many just do not understand the idea of tracking their learning process of seeing the uploading of reflective learning journal including discussion as essential thought and thinking process that will lead them to become a self-directed learner. Often we also see using technology to assist teaching and in this case using

LMS in the fostering of SDL as increasing teaching workload in terms of preparation, online assessment and giving immediate online feedback.

Table 5. Qualitative Responses - Learning Reflection of Different Learning Abilities

Learning Reflection
CASE 1 : Weaker and / or Less motivated **CJ** *This project has taught me how to integrate knowledge comprehended and acquired from associated modules such as structural analysis and BIM modelling. I also realized that importance of teamwork as this project requires a lot of discussions to find the most optimal sizing for our structural members. As there is no presentation for this report, it was important for us to take down meeting minutes to jot down our thought process. Through this project, I now understand the steps involved in design calculations.* **ST** *I learnt more about Buildable Design Score and BCA COP 2017 and why it needs to be carried out. I also learnt more about the thought process needed to be put into before carrying out the project work. I learnt that effective labour work is a very important key part of a project as it will definitely affect the dateline and progression. Finally, I learnt that the higher the Buildable Design Score the better as it shows that the project has efficient labour usage in construction and therefore higher site labour productivity. Overall, I felt that I learnt a lot from this project as when I was doing research, BCA COP 2017 provided me with many answers which were resourceful, hence I was able to broaden my knowledge even though they were not included in the report. Furthermore, our team worked well together by segregating our work and in the end all of us managed to complete the tasks on time. Overall, it was a good experience and learning process and I hope I can experience such a process in the future.* ***Aqil*** *Thru this project, it gives me the opportunity to use Revit and apply what I've learnt n Precast Technology module. Example would be how to calculate the Buildability Score and what components do I need to consider, columns, beams, walls, shafts,etc. Also, when I help the team with the 3D drawings, it showed me how much I have progress over the years in using such software. I love what I'm doing by far and with the help of my teammates I did better. Teammates were not as proactive at the start but as soon as we ask the lecturer for help and knowing what we need to do for this project, as soon as possible we have meetings and discuss on the project seriously. In conclusion, we manage to complete the calculations and 3D drawing.* ***Ja*** *Through this project, I have learned how to calculate the buildable design score of our selected building unit. With the help of the COP 2017 link and with our lecturer consultant, our group is able to solve all the calculation parts such as area of the structural system and the length of our wall system. After a long hour of discussion with my team we are able to gather and produce the final 3D revit model, with the revit floor plan and the layout we are able to calculate area and length to put in our table charts. I additionally learnt the importance of time management and communication since it's critical for everybody to understand their roles and there was a restricted time for this project. Our B-score overall is within range so is acceptable. Overall I felt that we did a good job completing this project.*
CASE 2 : Average ***LC*** *After doing this project, I learned that there is a lot of behind the scenes besides just designing the beam. Such things are bolting inside the truss to support the structure, checking for compression and tension. I've also learned how to apply what I have learned in this module, especially topic 4 and apply what I have learned from structural analysis in Year 2 to this project. Overall, the workload for this project is manageable due to our lecturer's advice on starting the project at a much earlier date and I would like to thank Mrs Soo for the advice to our team when we were stuck with a problem.*
CASE 3 : Good ***CLE*** *Through this project, I was able to have depper insight to the topics taught in class. I am now more confident with doing the calculations, especially for bolting and base plate. I learned to use Revit to design a signle stoey steel building and became more familiar with finding the right Universal Beams and Purlin Channels to put into the model. I also learned to draw a truss system from Revit which was easier now that I know there is a function in Revit to draw it, instead of having to manaully draw each truss member.*

These perceived perspectives, are seen as extra workload on top of what we are already doing in the classroom. However, the payoffs would be seeing weaker and less motivated students engaging in their group learning and together with others becoming self-directed learners. For the 25% negative responses because of a perceived lack of desire or commitment, I have to accept that there are always some students would have little desire to explore SDL and find it a chore to do reflective journal and discussion online.

In conclusion, this paper represents the work of a few iteration of an action research begin in 2018 in searching for continuous improvement in fostering SDL with the help of LMS. My experience in using LMS to foster SDL has taught me to look for the hidden barriers of the 25% who have little desire to explore self-directed learning. The next step in this action research is to develop ways of helping them remove the barriers.

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The Impact of Metaverse and Virtual Idols Technologies to Teaching and Learning

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Abstract

Metaverse has been a hot topic recently. There are increasingly virtual idols in the Virtual Reality world, such as virtual YouTubers (VTuber) and recently AESPA, formed by an entertainment company consisting of four real women and four artificial intelligence members in South Korea. As long as the technology matures, the virtual idol can perfectly present every action, and there will be no mistakes. However, in the past, virtual idols required live production support, dubbing and motion capture. Fortunately, artificial intelligence (AI) is becoming more and more mature nowadays, which significantly helps the development of virtual idols. For example, in natural language processing (NLP) projects, artificial intelligence models which can be trained through deep learning to develop some projects related to virtual idols. Question Answering Systems simulate human dialogue, and the system can return network results with highly accurate or straightforward answers. These techniques can help answer some common questions from students and reduce the workload of tutors. It can even help monitor students' online exams to prevent cheating. The world's technology giants have also developed related cloud technologies and Open source conversational AI, such as Chatterbot, Rasa or DialogFlow from Google Cloud Service. These tools can reduce the time and difficulty in developing virtual idols. In terms of Metaverse, following the trend of the virtual world, virtual idols in the immersive virtual world will also bring considerable business opportunities, such as VR movies and virtual concerts. More importantly, virtual idols do not need to rest, and they can work 24 hours a day means that people around the world can meet the virtual idol at any time.

Based on the situation, the demand for developers will also increase. Our team has also developed virtual idol projects using the above technologies, including IT Sarah, IT Hana and IT Sophia. IT Sarah and Hana are dubbed behind the scenes and captured in real-time, while IT Sophia is an AI chatbot.

Virtual experiments in the Metaverse can enhance the student experience through online virtual collaboration while learning about the nature of the Metaverse, team building, community development and digital citizenship.

Keywords: *metaverse, virtual idols, AR, VR, MR, XR NLP, artificial intelligence (AI), chatbot, google cloud service, NFT non-fungible token*

1. Introduction

1.1 Metaverse

The Metaverse is a network of 3D virtual worlds focused on social connections. It mainly discusses a persistent and decentralized online 3D virtual environment. This virtual environment will be accessible through virtual reality glasses, augmented reality glasses, cell phones, personal computers and video game consoles in the artificial virtual world. In terms of usage, the Metaverse is currently mainly limited by the technical limitations of the hardware devices and sensors required to interact with the real-time virtual environment. The Metaverse can be seen as a huge application of off-the-shelf technology, a virtual space. This virtual space requires various technologies such as blockchain, artificial intelligence, augmented reality, and machine vision. The Metaverse has considerable potential in computer games, business, education, retail and real estate. This article will explore how this concept can be incorporated into education. This article first studies the popular Metaverse technologies, including VTUBER and AESPA.

VTuber is Virtual YouTuber. The operator may be an entire team, including programming, motion control, voice actors, etc., or it may be just one person. The operator will use motion capture devices, sensors, facial technology, voice recognition, etc., to show character movements on virtual characters. VTuber can also communicate with fans in the real world in various ways. Some VTubers also use Live2D to create virtual character models and use software such as web cameras and facial motion capture to realize the models' actions.

AESPA is a four-member girl group launched by a well-known Korean entertainment company in 2020. This group consists of four members of different nationalities, and the group also has four AI members.

Another example is the Virtual Teresa Teng, at the 2022 New Year's Eve party, the Virtual Teresa Teng and the

famous Chinese singer Zhou Shen sang "Small Town Story" together, the show demonstrated the technology which can help the singers across time and space, the technology makes people feel full of emotion.

1.2 Natural Language Processing

Natural Language Processing (NLP) is a sub-discipline of artificial intelligence and linguistics. This field explores how to process and use natural language. It includes many aspects and steps, cognition, understanding, generation, and other parts. Natural language cognition and understanding let the computer turn the input language into interesting symbols and relationships and then process it according to the purpose. Natural language generation systems convert computer data into natural language.

Google LaMDA

LaMDA stands for "Language Model for Dialogue Applications." It is a machine learning-powered chatbot designed to talk about any topic, enhanced with better language understanding and language generation skills. However, it is only trained on text.

GCS DialogFlow

DialogFlow is another Google Cloud Service (GCS). Provides a natural language understanding platform to quickly design and integrate conversational user interfaces into your mobile apps, web apps, devices, bots, interactive voice response systems, and more. With DialogFlow, you can provide users with new and engaging ways to interact with your product. It can analyze many input types from customers, including text or audio input. It can also respond to your customers in various ways via text or synthesized speech.

So we started to research and use the following tools to cooperate with the above technologies to help in teaching.

2. Education

2.1 IT Sarah

IT Sarah's performance is free and easy, but the task is not easy. During the performance, performers should read the dialogue with accurate tone and tone, make corresponding actions synchronously, cooperate with the computer system, etc., to consider many aspects. Therefore, before the performance, we have to make detailed preparations. First, we had to inspect the site and study how to set up the supporting equipment. The student team used emerging mixed reality and motion capture systems combined with live video output software so that IT Sarah could interact with the audience in real-time. Students are responsible for controlling the entire system during the formal performance process. After repeated revisions, adjustments and repeated testing by the team, the ideal effect can be obtained. After the team has learned from experience, they have a more thorough understanding of the system and technology, which will help to make other virtual idols in the future.

Figure 1 IT Sarah Motion Capturing and Editing

2.2 IT Hana & IT Sophia

Similar to IT Sarah, the difference is that IT Sophia and IT Hana are in a Metaverse. Students use MOTION CAPTURE to transform into IT Hana, interact with artificial intelligence IT Sophia, and promote our activities and information.

2.3 ALL SCREEN

All Screens is designed to allow teachers to "close seven at a glance" and view all of their students' computer screens. Our team builds a cloud platform through Amazon Web Services (AWS) server architecture and uses AR and 3D animation to design "virtual assistant teacher Ma". Through a system where teachers ask students to share screens at all times, learn about students' computer activity, and through their pre-existing webcam setups, AI technology is used to detect the range of head movements to determine if students are distracted or suspected of cheating.

When students turn on their webcams, artificial intelligence technology is used in the background to recognize students' faces and detect their eyes, head movements and computer screens. Once suspicious, it will issue a warning or notify the teacher, increasing the difficulty of cheating in disguised form and acting as a deterrent.

3. Methodology

3.1 IT Sarah

The team started with modelling and selected the humanoid animation works created by graduates of the Higher Diploma in Games and Animation as the model for the appearance of IT Sarah. Mixed reality (MR) and motion capture systems, combined with live video output software, enabled IT Sarah to interact with the audience in real-time. During the entire formal performance process, students must be responsible for adjusting IT Sarah's movements, controlling the sequence of video

output, and previewing and combining effects with real-time video.

3.2 IT Hana & IT Sophia

The team used Epic Game's Unreal Engine and MetaHuman to create a unique realistic human model. The motion capture system combined with facial expressions enables IT Hana to show movements and expressions in virtual environments that are consistent with reality. During this formal performance, students are responsible for IT Hana's movements and their expressions, which help students master the smoothness and naturalness of animation movements.

The IT Sophia side uses Google's DialogFlow to conduct artificial intelligence answering training. After the training, students can communicate with IT Sophia in real-time, just like answering a natural person. Combining IT Hana and IT Sophia, a Metaverse can be created.

Figure 2 IT Hana Motion Capture Progress

3.3 ALL SCREEN

All Screens are developed with Amazon AWS technology and only need to open a web browser to use it. AWS cloud charges are calculated in thousandths of a second. It only takes half a second to one second for the system to capture the screen of the student. Starting with hundreds of students, if All Screens is used in each class, it will only cost a few dollars in operating fees for the entire semester. When it comes to the student experience, apart from invigilation, the most significant difference between weekday teaching and online teaching is that in the past, when students raised their hands, teachers would come forward to answer them; the classrooms were mainly laboratories, and it would be difficult to teach if students could not see the screen. Through All Screens, teachers can know which steps students are stuck in and give immediate guidance. If classes resume in the future, teachers can use this system to keep abreast of students' learning situations at any time, which is better than one-way teaching.

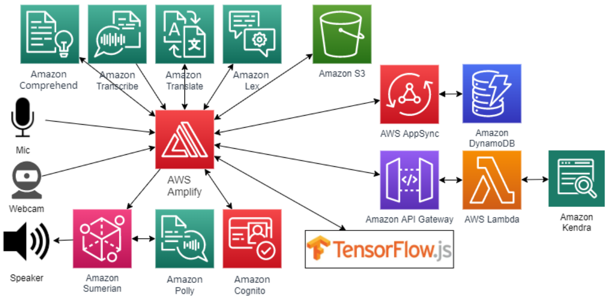

Figure 3 All Screen's Component Diagram

4. Result

All Screens saved our online courses during the COVID-19 outbreak. If the teacher only uses the existing online meeting tools, the online courses will likely get out of control. Many schools are also doing online tests or exams; this is just a test of a student's friendship or teamwork ability, not subject knowledge. If Amazon S3 version control is enabled, you can even record how students complete their assignments, thus solving cheating problems in online classrooms! Plus, virtual tutors add fun to the classroom with more interaction, and students can ask questions anytime, anywhere.

5. Conclusion

Today, with the maturity of technology, we may be able to imagine more virtual idol scenes that travel through time and space, AR/VR scenes used in various games, performance, teaching, promotion …etc, there will be more interactive ways between the teachers, students as well as the audience's virtual idols are also worth looking forward to.

In the future, our team will continue to bring more learning opportunities to students by optimizing three virtual idols, including tailoring various costumes to make the appearance of virtual idols more varied; and adjusting the system to more accurately capture the movements of performers. In addition, the information technology discipline will also encourage students to create other virtual idols to broaden their application and enrich their learning experience.

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Report on the Project-Based-Learning by Technical College Students in Collaboration with Local Government and Enterprise: Developing an Education Program of Disaster Prevention for Foreign Technical Intern Trainees

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Abstract

This paper reports on the Project-Based-Learning (PBL) practiced in National Institute of Technology, Tomakomai College, in collaboration with the local government and enterprises, and discusses its educational effects on the development of the students' generic skills.

In the year of 2019, our college launched a new course called "Frontier Course", which provides business-related subjects as well as engineering subjects, with the aim of developing human resources with not only engineering knowledge and skills, but also those of management. The course specifically aims to foster the innovative human resources who can proactively work on a local problem with a global perspective, and effectively collaborate with others to generate a new solution to it with their innovation mindsets.

For the achievement of the educational objective, the course provides a compulsory PBL subject called "Frontier Study Project", where the students challenge to solve a local problem in a team in collaboration with the local government and enterprises. In the year of 2020-21, 15 students participated in the study project, and conducted 4 respective projects splitting into 4 teams. One of the teams took on the challenge to enhance the local ability of disaster management through the development of a disaster prevention education program for foreign technical intern trainees at a local enterprise, and held disaster prevention workshops for them.

The results of self-evaluation questionnaire completed by the students indicated that the collaborative PBL worked effectively for the development of the innovative human resources, and cultivated the students' autonomy, problem-solving skills and team-working skills.

Keywords: *Project-Based-Learning, local-problem-oriented approach, Industry-Academia-Government Collaboration, disaster prevention education for foreign technical intern trainees, autonomy, problem-solving skills, team-working skills, intercultural communication*

Introduction

In an increasingly globalized world, where social issues continue to diversify, there have been growing needs for the development of global human resources who can proactively take on the challenge of solving the diverse social problems with high level of problem-solving skills and effective communication skills to work with others [1][2]. To meet such social needs, the National Institute of Technology, Japan, has aimed to foster innovative and practical engineers, "Social Doctors", who solve social issues with the power of science and technology [3].

In 2019, Tomakomai College launched a new course called "Frontier Course", and embarked on a distinctive education with the aim of developing innovative human resources with engineering and management perspectives.

Tomakomai College has 5 engineering divisions, and each division is divided into 2 courses in the 4th year; one is Specialized Engineering Course that provides specialized engineering subjects of the field, and another is Frontier Course that provides business-related subjects in addition to engineering subjects. That makes Frontier Course a mixture of students with 5 different engineering fields. Figure 1 shows the innovative human resources, whom Frontier Course aims for, with 4 key competencies.

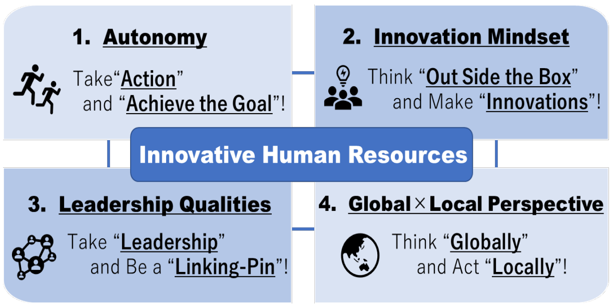

Fig. 1. Innovative Human Resources with 4 competencies

Specifically, the type of innovative human resource to be developed in the course is described in the following.

1. Take "Action" and "Achieve the Goal"

A person who has autonomous and independent attitude toward his/her own thinking and learning, and can translate his/her thoughts into action: setting a goal, making a plan, and executing the plan to achieve the goal.

2. Think "Outside the Box" and Make "Innovations"

A person who can give a new solution to a problem by thinking outside the box and making innovations: combining new and existing knowledge, resources, equipment and other factors to generate new ideas as defined by Schumpeter [4].

3. Take "Leadership" and Be a "Linking-Pin"

A person who has leadership qualities, including effective team-working skills to work with others, to unite a diverse group of people and encourage others to achieve the goal together. The person serves not only as a team leader but also as a "Linking-Pin" to make connections between others and hold them together [5].

4. Think "Globally" and Act "Locally"

A person who can work on a local problem with a global perspective, which is based on the awareness of

the world's trends, the interests in both international and local communities, and the adaptability to the diversity of the current world.

In order to develop such innovative human resources, Frontier Course offers a compulsory PBL subject called "Frontier Study Project". In the 18-month study project, the students challenge to solve a local problem in a team in collaboration with the local government and enterprises. Figure 2 illustrates the framework of Frontier Study Project with 4 essential conditions to be fulfilled.

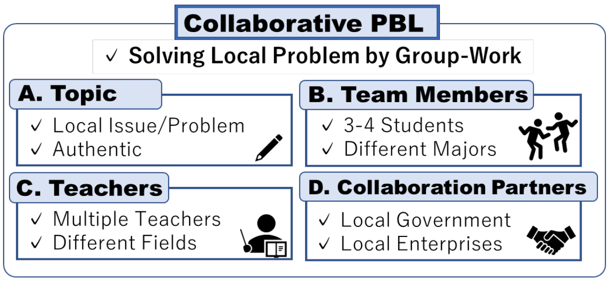

Fig. 2. Framework of Frontier Study Project

T
he following are the details of each condition:

- ***the project topic*** is to be authentic and a real issue that exists in local communities or enterprises. **(A)**
- ***the team*** is to be composed of 3-4 students from different engineering fields so that they can share their different engineering knowledge and skills to create a new idea together to solve a problem. **(B)**
- ***the teachers*** who supervise the project is to be multiple and have different areas of expertise, so that the students can be given expert guidance and advice from their respective fields of expertise. **(C)**
- the project is to be conducted with ***collaboration partners***; the local government and enterprises. **(D)**

In the year of 2020-21, 15 students participated in the project, and conducted 4 respective projects splitting into 4 teams. One of the teams took on a challenge to enhance the local ability of disaster management through the development of a disaster prevention education program for foreign technical intern trainees at a local enterprise, and held disaster prevention workshops for them.

This paper reports on the details of the project, and discusses its educational effects on the development of the students' generic skills, based on the results of self-evaluation questionnaire completed by the students after the completion of the project.

Method

1. Outline of the Project

The outline of the project is shown in Figure 3, and the details are described in the following.

A. ***Topic***

The city of Tomakomai, Hokkaido, is subject to a variety of natural disasters, such as earthquakes and tsunamis, due to the geographical and topographical conditions. In the year of 2018, a large-scale earthquake with the magnitude of 6.7 struck the southwest area of Hokkaido, and caused great damages to the city. Despite the fact, however, even after the earthquake, the city had not taken sufficient countermeasures against disaster prevention for foreign residents whom the city had been accepting over the years. Acknowledging such a local situation to be a serious issue, the supervising teachers of the project decided to make it the project topic, which is to develop an education program of disaster prevention for the foreign residents, and enhance the local ability of disaster management of the city.

B. ***Team Members***

The team consisted of 4 students; 3 in the division of Civil Engineering, and 1 in the division of Computer Science and Engineering. The Civil Engineering students applied their knowledge of Hydraulics and Geotechnics to the experiments of teaching the mechanisms of earthquakes and tsunamis, while the students in the division of Computer Science and Engineering applied her programming skills to creating a questionnaire form with Microsoft Forms, and making teaching materials of disaster prevention workshop with Microsoft PowerPoint.

C. ***Teachers***

2 teachers were assigned to supervise the project; one is an associate professor of International Understanding Education in the division of Humanities and Social Sciences (= the first author), and the other is a professor of Disaster Prevention Engineering in the division of Civil Engineering (= the second author). The teachers worked collaboratively in supervising the project and provided technical guidance and advice from their different fields of expertise respectively.

D. ***Collaboration Partners***

1) ***Disaster Management Division*** **of Tomakomai City**

It is a division within Citizen Affairs Department of Tomakomai City, and is responsible for the local disaster management. In the project, they provided their expert advice for the students designing and creating the disaster prevention workshops and the teaching materials based on their detailed knowledge and experiences.

2) ***ISUZU Engine Manufacturing Hokkaido Co., Ltd.*** **(*ISUZU Engine mfr.*)**

It is a local enterprise to manufacture engines and automotive parts for *ISUZU Motors Limited*. They have been employing technical intern trainees from Vietnam, and the project was targeted at those intern trainees. In the project, *ISUZU Engine mfr.* provided their cooperation in conducting surveys on the trainees, and holding disaster prevention workshops at the workplace.

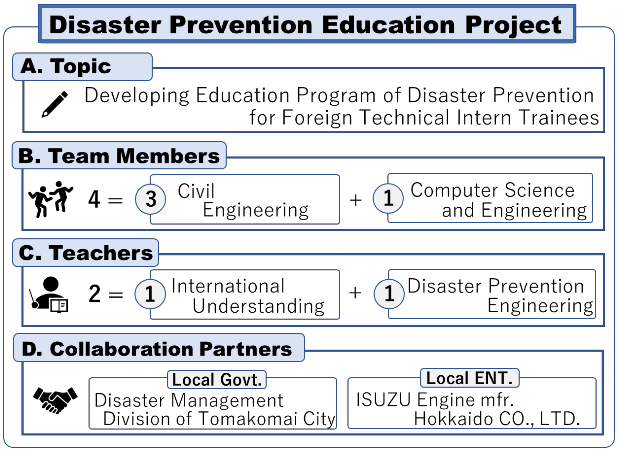

Fig. 3. Outline of the Project

2. Procedures

The procedures of the project are shown in Figure 4, followed by the description of the details.

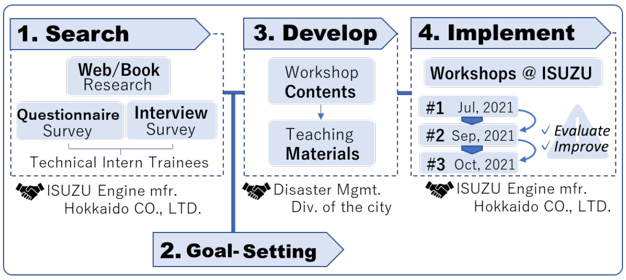

Fig. 4. Procedures of the Project

2.1 Search

1) Book / Web Research (Oct. 2020 – Mar. 2021)

At the begining of the project, the students obtained the following information from International Relations Division of Tomakomai City.

- ➢ The number of foreign residents of the city has been increasing, and Vietnamese constitute the largest and most growing group among them.
- ➢ Most of the Vietnamese residents are technical intern trainees woking at local enterprises, who are provided the job opportunities on Technical Intern Training Program run by Japanese government.

Based on the information, the students researched on the disasters in Vietnam and found the following.

- ➢ Vietnam is prone to water and wind-related disasters, such as floods and torrential rains, and rarely has earthquakes and tsunamis unlike Japan.
- ➢ Thus, disaster management education practiced in Vietnam mainly focuses on water and wind-related disasters, and people in the country have limited awareness or knowledge of earthquakes and tsunamis.

2) Questionnaire Survey (Feb. 2021)

The students conducted a questionnaire survey to foreign technical intern trainees in Tomakomai to ask their demographic information, their knowledge of natural disasters, and their experience of earthquakes in Japan. The questionnaire was sent to 96 local enterprises, and 41 intern trainees responded to it: one from China with no information on his place of employment, and 40 from Vietnam in the employment of *ISUZU Engine mfr.*

The responses indicated that most of the respondents had little experience of large-scale earthquakes, and that they had limited knowledge of disaster prevention, which is essential to live in the disasters-prone country of Japan.

The following are some of the responses obtained in the questionnaire, which the students found important for their research.

- ➢ All of the respondents had been in Tomakomai for less than 3 years (*at the time of the survey), and only 3 respondents (7%) experienced the large-scale earthquake that occurred in Hokkaido in 2018.
- ➢ 24 respondents (66%) had never read the Disaster Prevention Handbook published by Tomakomai City, and that included 18 respondents (44%) who had not known the existence of the book.
- ➢ 17 respondents (41%) gave incorrect answers to a quiz question for testing their understanding of Tsunami Hazard Map, which shows the areas of the city that can be at risk of inundation when a tsunami occurs.

3) Oral Survey (Jun. 2021)

In order to gather more authentic data from the respondents, the students conducted an interview survey to the Vietnamese intern trainees at *ISUZU Engine mfr.* From the interview, the students leant the following.

- ➢ Most of the intern trainees speak only Vietnamese, and are not fluent in both Japanese and English. That makes it extremely difficult to achieve oral communication with them.
- ➢ Most of the technical intern trainees have limited knowledge of effective evacuation at the time of disasters, especially an earthquake, and are not sure what actions should be taken until fleeing to safety.

Fig. 5. Interview with Vietnamese intern trainees

2.2 Goal Setting

Based on the results of the surveys, the students decided the end-goals of the project to hold a disaster prevention workshop for Vietnamese technical intern trainees at *ISUZU Engine mfr*. with the following aims.

I. To raise their fundamental knowledge and awareness of disaster prevention, especially those of earthquakes and tsunamis.

II. To get them to understand specifically what actions need to be taken for effective evacuation in the event of a large-scale earthquake.

2.3 Develop

1) Workshop Contents

In order to accomplish the end-goals, the students determined the contents of the workshop as shown in Figure 6 and Table 1.

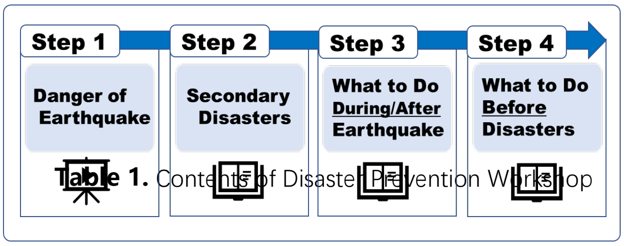

Fig. 6. Outline of Disaster Prevention Workshop

Table 1. Contents of Disaster Prevention Workshop

Step 1: Danger of Earthquake
Get the participants to watch a video of the Great East Japan Earthquake in 2011, which triggered the greatest tsunami ever recorded in Japan and caused tremendous damage to the northeast part of Japan including more than 18,000 dead or missing persons.

Step 2: Secondary Disasters of Earthquake
Explain secondary disasters caused by earthquakes, such as tsunamis, fires and building collapses, and explain the damaging effects to infrastructure, such as water, power supplies and communications systems.

Step 3: What to Do During/After Earthquake
Teach six things to do during and after an earthquake for effective evacuation, which include how to collect accurate disaster information from trusted sources so that they will not be misled by false information, which often spread during a large-scale disaster.

Step 4: What to Do Before Earthquake
Explain what to do to prepare for natural disasters, which includes preparing an emergency bag and checking the locations of evacuation shelters and sites on a map in the Disaster Prevention Handbook.

The contents of the workshop, including the teaching materials, were checked by Disaster Management Division of Tomakomai City before implementation.

2) Teaching Materials

Giving due consideration to the participants' limited Japanese language proficiency, the students developed their own teaching materials on Microsoft PowerPoint with a lot of pictures, videos and simple Japanese. The materials included demonstration videos that the students shot at the technical interns' residence to show a series of actions to be taken in the event of an earthquake.

Figure 7 is an example of the teaching materials.

Fig. 7. Teaching Material for Step 2 (in Fig 6)

2.4 Implementation

The students conducted disaster prevention workshops three times at *ISUZU Engine mfr,* and a total of 34 tehnical intern trainees from Vietnam participated in them. The date and the number of the participants of each workshop is shown in Table 2.

Table 2. Dates and Participants of Workshops

	Date	# of Participants
1st workshop	Jul. 15, 2021	12
2nd workshop	Sep. 17, 2021	12
3rd workshop	Oct. 15, 2021	10

"What Would Happen After an Earthquake?"

After each workshop, the students held an evaluation meeting and disucssed improvement points to be made for the next workshop; specifically, in the first and second workshops, they found that Japanese langauge used in the workshops was not easy enough for the participants to understand, and that the workshop lacked interaction between them and the participants. Thus, they made the following improvements to the last workshop.

- Adding many pictures and animations to the teaching materials so that the participants with limited Japanese language proficiency can visually understand the contents of the workshop.
- Adding a group-work activity to the workshop where the participants work on a review-test together with others in a group.
- Bringing the actual objects to the workshop, such as emergency bags or breakers, and teach them how to use them in the event of earthquakes by getting the participants to actually touch and use them.

Fig. 8. Disaster Prevention Workshop at *ISUZU Engine*

Results and Discussion

In order to verify the educational effects of the collaborative PBL for the development of the innovative human resources described in Figure 1, we asked the students to complete a self-evaluation questionnaire after the completion of the project. In the questionnaire, they were asked to evaluate the following competencies of their own on a five-point scale as their pre- and post-project competencies.

1. ***Autonomy***
2. ***Problem-Solving Skills***

3. ***Team-Working Skills***

In addition, they were also asked to answer the following free-response questions.

Q1. What abilities or skills did you improve the most thought the project?

Q2. What abilities or skills would you like to improve for your further self-improvement?

As shown in Figure 9, the results of the questionnaire indicated that the collaborative PBL worked effectively for the development of the innovative human resources which Frontier Course aims for, in respect that the students improved their generic skills required for the desired human resources in the project. Moreover, the results suggested that the PBL raised the students' self-awareness, and that helped them to identify the areas to work on for their further self-improvements.

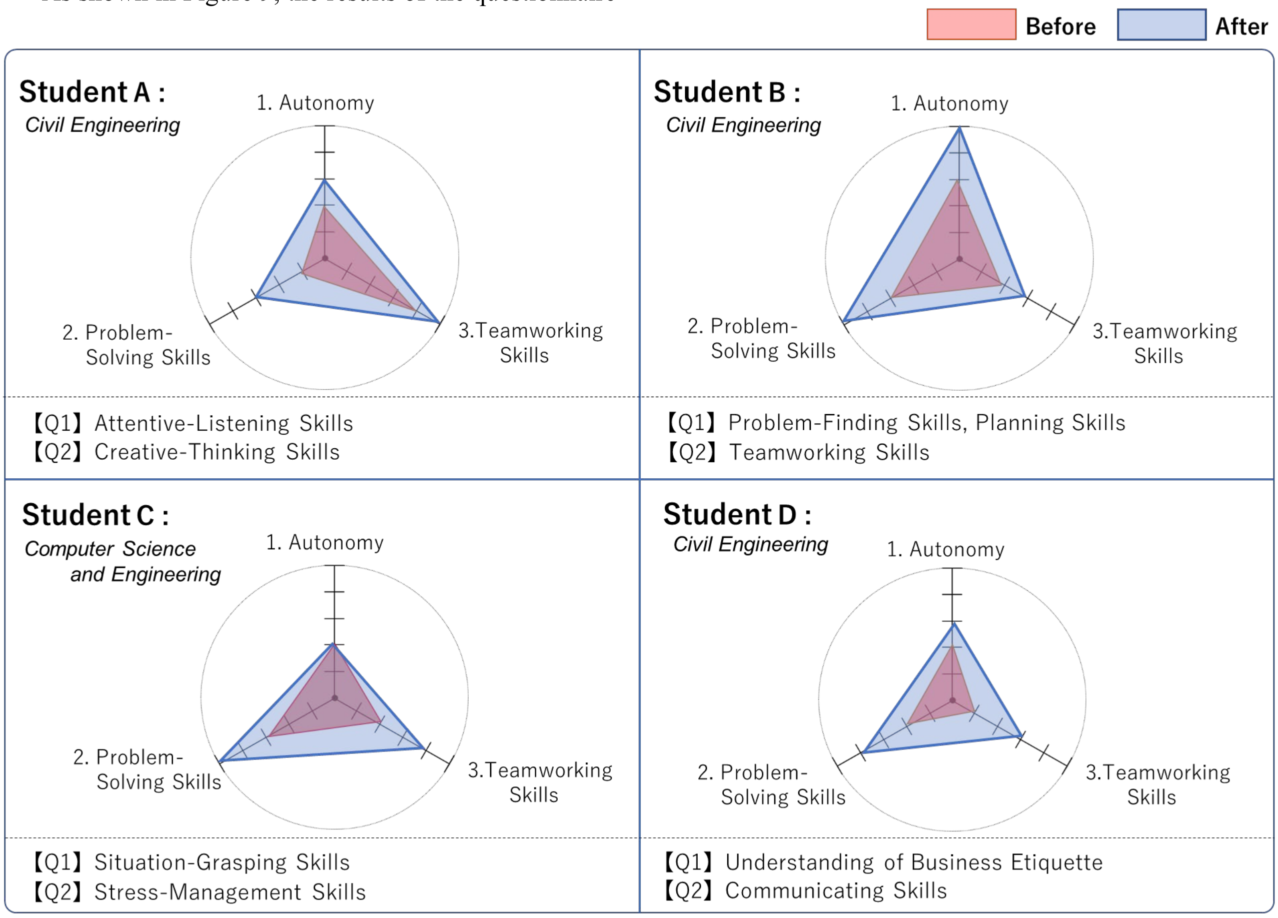

Fig. 9. Results of Self-Evaluation Questionnaire

1. Individuals

1) Students A

As shown on the radar chart in Figure 9, Students A, who served as a team leader in the project, gave the highest score on the team-working skills as his post-project competencies while the problem-solving skills showed the most significant improvement comparing the pre- and post-project scores.

In response to Q1, he stated that the project encouraged him to improve his team-working skills, especially attentive-listening skills, as follows:

➢ *As a team leader, I always tried to attentively listen to the other members' ideas and opinions in the discussions, and that made me realize that **the others had ideas and knowledge which I had never come up with or owned**. I found it quite interesting, and **that made me want to listen to them more.***
(author's translation)

The comment indicates that his attentive-listening skills were developed through the process of fulfilling his responsibilities as a team leader. In response to Q2, he stated that he would like to improve his creative-thinking skills, explaining the reason as follows:

➢ *I was always impressed by the creative ideas that the other members come up with, and I often felt like I didn't have the kind of creativity. So, I would like to **improve my creative-thinking skills** and **see things from multiple perspectives**.(author's translation)*

His response shows that the collaborative work in the project gave him an opportunity to be exposed to a variety of ideas and knowledge of others, which he would never be able to meet in an individual work, and that such an exposure increased his self-awareness of his strength and weakness.

2) Students B

As the radar chart in Figure 9 shows, Students B gave the highest scores on autonomy and problem-solving skills as her post-project competencies, both of which showing the biggest improvement comparing the pre-

and post- project scores.

In response to Q1, she stated that the project cultivated her problem-finding skills and planning skills, and gave the following comment.

- *Through the project, I became able to* ***identify what needs to be done*** *and* ***how it should be done for the end-goals****, and* ***make a plan for executing them.*** *(author's translation)*

The comment indicates that the project fostered not only her problem-finding skills but also her goal-setting skills; identifying what mean-goals need to be set, and how and when they should be accomplished toward the end-goals. Recognizing the positive changes to her abilities as an individual, however, she answered to Q2 that she would like to improve her team-working skills to work with others more collaboratively, based on the awareness that an individual's ability itself would not necessarily lead to the greater team-performance.

3) Students C

As shown on the radar chart in Figure 9, Students C gave the highest score on problem-solving skills as her post-project competencies while the scores on autonomy remained the same before and after the project.

To Q1, she answered that she improved her situation-grasping skills in the project; with which she identified what the other team members needed assistance for, and provided the needed assistance to them, especially that of her specialized field, computer science and information technology.

In response to Q2, she stated that she would need to build better stress management skills as she sometimes found herself having difficult time in handling stress caused by working with others. Her response shows that the collaborative PBL helped her to recognize her own weakness, which she would not be able to recognize in an individual work. Since she will surely encounter many occasions to collaborate with others in the real-world, the obtained awareness in the project is significant for her to achieve further self-improvement.

4) Students D

As the radar chart in Figure 9 shows, Students D scored highest on problem-solving skills as his post-project competencies while the team-working skills also indicated the biggest improvement comparing the pre- and post-project scores.

In answering Q1, he stated that the collaborative PBL gave him an opportunity to learn social rules and manners, giving the following comment.

- ***By collaborating with the local government and enterprises*** *in the project, I could learn* ***social rules and business manners*** *required to work with others in the real-world. (author's translation)*

His comment shows that the repeated communication with the collaboration partners in the project gave him a real-world experience and encouraged him to acquire an essential quality to become a Linking-pin, who needs to establish a trusting relationship with others.

In response to Q2, he stated that he would like to improve his communicating skills to express his opinions more actively and confidently as he sometimes found himself hesitating to speak up in group discussions. As the reason behind it, he analyzed himself that he had a tendency to overthink before speaking up. Again, his response indicates that the collaborative PBL raised his self-awareness of his weakness, which he could not become aware of by working alone, and encouraged him to identify the areas to work on for his further self-improvement.

2. Overall

Overall, all the students self-evaluated that they improved their problem-solving skills and team-working skills in the project while the improvement of problem-solving skills was the most significant for all. This is most likely because they repeatedly went through the process of problem-finding and solving throughout the project toward the end-goals. For example, in the early stage of the project, the students had an assumption that they could solve the local problem by simply translating the Disaster Prevention Handbook, which had already been published by the city, into "English". However, as pursuing their research, they began to find out what was actually going on in the real-world and got a detailed picture of it; the majority of foreign residents of the city were non-native English speakers with limited Japanese proficiency, and many of them had little experience or knowledge of earthquakes and tsunamis due to the geographical and topographical conditions of their home country. Such realization to the real-world led them to the complete destruction of their deep-rooted assumption, which was "Cross-cultural Communication = English". This unexpected obstacle made them rethink about the social problem from the ground up, and realize that they needed to find a new solution to it by thinking outside the box, not just simply translating the already existing knowledge and resources into a different language. In other words, the collaborative PBL encouraged them to solve the local problem not only with a global perspective but also with innovation mindset. That is how they ended up with developing their own education program and materials using a lot of non-verbal communication tools. This is only one of many challenges they encountered throughout the project, but every time they faced the obstacles, they proactively and even persistently took on the challenges and found their own solutions using their innovation mindsets. It is believed that such repeated challenges in the project cultivated their problem-solving skills significantly.

Conclusions

This paper reported on the collaborative PBL practiced in National Institute of Technology, Tomakomai College, and discussed its educational effects on the development of the students' generic skills. In the local-problem-oriented PBL, which was designed for the development of the innovative human resources, 4 students in a team took on the challenge to enhance the local ability of disaster management, and developed an education program of disaster prevention for foreign technical intern trainees at a local enterprise. Although it was quite a challenge, the students managed to develop the education program in collaboration with the local

government and enterprise, and held disaster prevention workshops for the foreign trainees with their originally created teaching materials.

The results of self-evaluation questionnaire completed by the students indicated that the collaborative PBL worked effectively for the development of the innovative human resources in respect that the students improved their generic skills required for the desired human resources, such as autonomy, problem-solving skills and team-working skills. Especially the improvement of the problem-solving skills was the most significant for all the students, and it could be assumed that the specific skills were cultivated through the repeated process of trial and error they experienced in the project.

In order to verify the educational effectiveness of the collaborative PBL for developing the innovative human resources to a greater extent, further research with a bigger number of the students is necessary in the future.

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Career Education Starting from "General Chemistry with Thai Students"

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Abstract

Four years have passed since Ibaraki National College of Technology welcomed its first class of Thai students as a global KOSEN. What are the general chemistry classes at the college of technology like that are easy to join and attractive to new students, both Japanese who are inexperienced in English and Thai who are inexperienced in Japanese? We have been trying a new approach in the lower grades by making active use of life science, which we have working on with our undergraduate students, and ICT, which is attractive to students. In our classes, we paid attention to the following three points: (1) speak slowly and clearly in both Japanese and English, using simple words and concise expressions, and (2) prepare handouts summarizing key points in both Japanese and English, based on Japanese high school textbooks, and (3) expand the circle of group work from two students in the beginning, then four, so that no student would be left alone. Two foreign students, who had to take the first class remotely due to their late arrival in Japan, were also brought into groups of Japanese students, separately, and allowed to participate in group work. In the first class of the last fiscal year, the students learned what kind of substances coronaviruses are made of and what kind of chemical reaction is involved in "sterilization" with alcohol and soap. They also conducted a sterilization experiment using bacteria collected on agar plates from somewhere each student is interested in and considered the effectiveness of sterilization in preventing infection with coronaviruses from a chemical perspective. These series of attempts led to the discovery of individual abilities that could not be seen in a lecture-type class, not only for students who did not have time to interact with their friends in middle school, but also for students with characteristics including learning disabilities. In this presentation, we will report on Ibaraki National College of Technology's efforts to discover the strengths of individual students from the early grades and to link this to career education.

Keywords: *Thai students, lower grades, life science, ICT, group work, sterilization*

Introduction

It was in the academic year 2018 that graduates of the secondary school of Thai Princess Chulabhorn Science High School entered Ibaraki National College of Technology as first-grade students for the first time. Since then, Ibaraki National College of Technology has undergone four years of trial and error as the first global KOSEN as reported by Isaka *et al.* (2016), and in April of this year, the first students entered the 5th grade. One of the authors, Chiba, teaches general chemistry for first- and second-year students and physics for third-year students, as well as supervising graduation and special research for majors in biochemistry and biophysics. Nita, the other author, provides in-class support to first-year international students from Thailand in six subjects, in which they study together with Japanese students in their classes (Basic Math I, Basic Math II, Physics, Chemistry, Global Life Science, and Global Awareness). In addition to in-class support, Nita also provides after-school study support and mental and daily life support. In this paper, we report on our collaborative efforts in a chemistry class where both Japanese freshmen and Thai students before taking the Japanese Language Proficiency Test (JLPT) were studying together, and the effects on the subsequent career education of both Thai and Japanese students.

Textbooks and Handouts

The following materials were used for the classes: (1) textbook, (2) handouts, (3) review questions, and (4) on-demand class videos. As the textbook for the chemistry class, we used an authorized Japanese textbook with English accompanying keywords. At Ibaraki National College of Technology, the entire scope of "Basic Chemistry" and "Chemistry" is studied in the first and second year, so the first-year students study "Basic Chemistry" as well as a part of "Chemistry". Because of the wide scope of study, handouts were prepared for each class. Since there are several students in the class who are extremely slow in writing notes, by distributing handouts

in which students only need to write important keywords, it allows everyone to have time to concentrate on listening to the explanations and participating in group work. Students who did not finish writing their handouts after waiting a sufficient amount of time were allowed to freely take pictures of slides and the black board with their smart phones. However, in order to prevent students from using their smartphones for playing games during class, we informed them that if they used their smartphones for purposes other than class, we would hold their devices for a certain period of time, which also served as training for students to be able to limit their use of their own devices at will. Textbook problems were also placed on the handout to provide space for students to write calculations and explanations. The space was made wide enough for students who have difficulty writing small letters. Since it is difficult for first- and second-year international students to read the entire textbook in Japanese, the handouts contain about four pages per class, which are necessary for understanding the class. The handouts were distributed to all students. In the beginning, we put kana beside all kanji, but as the Japanese proficiency of Thai students improved, the number of furigana was gradually reduced. Bracket for putting English were prepared, so that students who could spare the time could write them in both English and Japanese. Thai students wrote keywords in both Japanese and English. The corresponding pages of the textbook were also written so that students could refer to the textbook if necessary. The full text of the class slides was also written Both in Japanese and English, and handout and review questions were provided in pdf format via Google classroom each week, as well as on paper. For students who were unable to attend class in Corona or who could not understand the content after listening to one class, lecture videos of each class were also made available from the Google classroom along with the handout. Although students are encouraged to write on the downloaded handouts with their tablets, few first-year students still use their tablets to take notes.

Class slides and online materials

The class was conducted using Power Point slides, and the minimum necessary content was recorded and made into mp4 format as a lecture video for review. We tried to speak slowly in concise, easy-to-understand Japanese to help students learn Japanese. Based on our own experience at an international academic conference, we tried to make the lecture easy to understand for students whose native language is not Japanese. Japanese students who had to stay at home in Corona and took the class on demand watched it at twice the speed.

Explanations in English in the classroom

In class, we first explain the slides in slow Japanese. Since it is difficult to understand the explanation if the words on the slides are different from the words used in the explanation, we tried to pronounce the words slowly and clearly while following the words on the slides as much as possible. Since superfluous interjections also interfere with listening comprehension, we used simple, short sentences to explain. Since the students from Thai Princess Chulabhorn Science High School are fluent in English, we followed the Japanese explanation with an explanation in English. We tried to keep the sentences as short as possible and to use simple words so that the Japanese students could easily understand. Surprisingly, the Japanese students listened to the English explanation with great concentration. In the class evaluation questionnaire, one student commented, “It was good to learn chemistry in both Japanese and English”. We tried explaining in English in a class without Thai students, but the students did not feel as concentrated as in the class with Thai students. We believe that the presence of Thai students increased the percentage of students who felt closer to the need for English and wanted to understand the class content in English.

Attempts to memorize Key words with games

At the beginning of high school chemistry, students need to memorize the periodic table and types of chemical bonds, which are necessary for subsequent studies. Compared to general high school students, technical college students have a lot to learn. Therefore, we devised a way to make them remember these keywords in class in a fun way. Because of the corona, the number of students who could not communicate with their classmates increased. We first introduced games to trigger their communication, such as a game in which they had to compete for time in groups, and a four-choice quick-punch game that they could work on using their individual cell phones or computers. For example, in the "Periodic Table Relay," students were divided into groups by rows of desks in the classroom, and each group was asked to use chalk as a baton to write one element on the blackboard from atomic number 1 to 20. The team with the fastest time to finish writing the 20th element, calcium, was the winner. This has become an annual event in which students who have just entered the school cooperate with each other and participate in the game, which helps to relieve tension.

Making "mol" feel familiar

The amount of substance "mol" is an essential part of learning chemistry, but at the same time, mol is a trigger for many students to become poor at chemistry. In Ibaraki Prefecture, where Ibaraki National College of Technology is located, there is a local character named "Mol-chan. Students these days, regardless of nationality, can "feel" natural phenomena through virtual characters and animated simulations. In many cases, animations are more intuitive and easier to understand than educational videos of experiments. By first promoting sensory understanding through the setting that "Mole-chan" is made up of 6×10^{23} atoms and molecules, students can smoothly build a bridge to calculation problems.

An experiment to study the effects of sterilization

In the first class of first-year students, as an example of "Chemistry in Daily Life", they learned about the chemical changes that occur in the sterilization process of bacteria and viruses. They also learned about the components of the vaccine of COVID-19 and how it differs from the viruses. Since they have not yet learned about the chemical formulas of the components of cell membranes and proteins that make up viruses, or the compounds soap and ethanol used for sterilization, they did not learn the details of the molecular structure. First, a brief explanation was given on the fact that these molecules are all organic compounds and how the bacteria are destroyed by soap and ethanol, and the principle of sterilization. Next, an experiment was conducted to compare the effectiveness of the sterilization. In the experiment, one piece of eutrophic agar medium and a cotton swab were distributed to each pair of two students. Each group could choose any location in the school as their experimental target. Using two cotton swabs, students collected bacteria from the experimental target before and after sterilization and inoculated them on agar medium. The method of sterilization was chosen from products using ethanol, hypochlorous acid, etc., or a sterilization sheet that the students carried with them. In the following week's class, the number of bacteria obtained from the specimens before and after sterilization was compared, and the effectiveness of each of the daily sterilization practices was compared, confirming that hand washing was highly effective method of sterilization.

Group work

For Thai students, whose numbers are small, communication with Japanese students is an indispensable item for their subsequent life at a Ibaraki college. On the other hand, since relationships among Japanese students tend to be weak due to the corona, many students are able to talk with their classmates for the first time when they are given a theme in class. In our classes, we often have group discussions lasting a few minutes. For example, when answering yes or no to a question, students are asked to confirm their answer with several people sitting close to them in advance so that they can feel comfortable raising their hands. Individually check to see if any students are not participating in the discussion and call on nearby groups to invite in isolated students. The two Thai students were guided to join separate groups of Japanese students. Gradually, the circle of discussion was extended to the entire class, creating an atmosphere in which students felt comfortable speaking up during class.

Periodic examinations

The examinations are written in both English and Japanese, and students may answer in either English or Japanese. Some non-returnee Japanese students boldly continued to answer all questions in English. Thai students also began to write answers to most of the questions in Japanese in the second semester of their first year.

Individualized Learning Support

Immediately after the entrance ceremony, we provided Thai students with careful preparation before classes. Last year, the first week of classes coincided with the quarantine period associated with immigration, so we explained how to participate in classes via Google meet, print out handouts before class, explain how to participate in the periodic table relay remotely, and how to check and submit assignments via google classroom. We also explained how to check and submit assignments via google classroom. After the students' arrival in Japan, supplementary lessons were held after each class, focusing on practicing Japanese vocabulary in the handout and reading and solving questions in Japanese. In the first semester, Nita accompanied the students to all classes, but in the second semester, we reduced the frequency, and guided them to manage the submission of assignments on their own. At this point, we paid special attention to facilitate group work with Japanese students. For the periodic examinations, we checked the points to pay special attention to in this class, such as significant figures and units, and had the students solve the practice problems in the Japanese question booklet with English translations.

Advantages for Thai students to study with Japanese

Thai students spend much of their time in Japanese classes. Some of them have already studied science before coming to Japan. In particular, they are overwhelmingly superior to Japanese students in English, so they lead Japanese students in Global Awareness and Global life science classes conducted in English. In other subjects taught mainly in Japanese, they sometimes participate in classes with the support of Japanese students during their first year, but in most cases, by their second year, they are often seen teaching in Japanese to their classmates. Many Japanese students are attracted to the sight of them working hard in their studies and extracurricular activities. Compared to foreign students who enter the third year of school after mastering Japanese, they seem to develop stronger bonds with Japanese students, respecting each other's individuality and growing up in a relaxed manner.

Advantages for Japanese students to study with Thai

Classes with Thai students generally have stable grades. One advantage is considered to be the fact that a support teacher in addition to the subject teachers is watching over them in the back of the classroom. However, the biggest advantage is that students can see the excellent Thai students who came to Japan in the first

grade spend a lot of time to learn a foreign language, Japanese, and try hard to understand the Japanese lessons even though their Japanese language skills are not good enough. For Japanese students who want to work abroad in the future but are not yet proficient in English, this is a familiar and significant goal. It is a valuable opportunity for them to think about what they can do to help others, not only in their studies but also in their daily lives. .

Benefits for Japanese students in need of assistance

Class materials and videos prepared for Thai students provide clear explanations and instructions, especially in concise language. All assignments were submitted via google classroom so that homeroom teachers and support teachers could check them together to ensure that nothing was missed. This made it easier to manage assignments for students who had been confused by the wide variety of ways in which assignments were communicated, such as email, orally, in print, and in the classroom.

Benefits as career education

With the arrival of Thai students from the first year, the use of English in class became routine and was recognized as a useful tool for communication. While the Japanese students were shocked to find that the Thai students were fluent in English when they entered the school, they also realized that they could share many things with each other as friends of the same age. It is a great achievement of the Japan-Thailand project that the students have come to respect each other's country and language as one of their personalities and to exchange friendship without using the special term “international exchange”. This has led to a change in the relationship between Japanese students, and in a positive sense, students have come to respect each other's individuality in their school life. The fact that the border between their own country and other countries has been lowered, that they have come to appreciate each other's wide-ranging individuality, and that they have felt the need to communicate their ideas in English, a universal language, will be valuable experiences for students who will live in the global society of the future.

Conclusions

More than four years have passed since we welcomed Thai students as Global KOSEN. We have provided support in simple and clear English to match the speed of Japanese language acquisition of the Thai students. This has proven to be helpful in lowering the barrier for Japanese students to feel comfortable with English, as well as in supporting Japanese students with learning disabilities. By incorporating group work, presentations, and competitions into the classes, we were able to discover the personalities and characteristics of classmates that were not apparent in lecture-based classes, and more students were able to build relationships that respected the individuality of each student.

References

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ASSESSING STUDENT LEARNING IN REAL TIME FOR ENGINEERING MATHEMATICS

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Abstract

Exit Tickets are assessment instruments in the form of short mathematical exercises with a confidence level questionnaire, providing a holistic view of students' learning in real time such as students' aptitude, confidence levels and areas of learning needs. Instructors then adjust the execution of the remaining lesson. It is also a good checkpoint for students to know what topics they need to work on.

This paper reflects on the design and implementation of Exit Tickets, how they contribute to the learning experience, and how the student assessment data gathered improve response strategies for the class according to class profile.

Keywords: *Exit ticket, assessment instruments, students' learning, aptitude, confidence level, assessment data, response strategy, class profile*

Introduction

Higher Education Consultant Dr. Peggy Maki advocates the need for continuously assessing students' progress to become the assessment norm across colleges and universities in her nation, USA. She believes that real time student assessments help educators in higher institutes of learning identify and address patterns of student obstacles requiring timely interventions. She adds, this improves student achievement and degree completion rates amidst continually diversifying student demographics, representing broad ranges of academic preparation and readiness and personal needs (Maki P. 2017). At the same time, Eric Darsow's workshops on "Implementing Real Time Assessments during Lessons" at his community college are instructive of good practices for gathering student learning data and reacting to that data within a lesson (Darsow E. 2017-2020). Elsewhere, Emelina Minero reports on how intensive real time assessment through different tools are providing a window to student learning at a senior high school (Minero E. 2017).

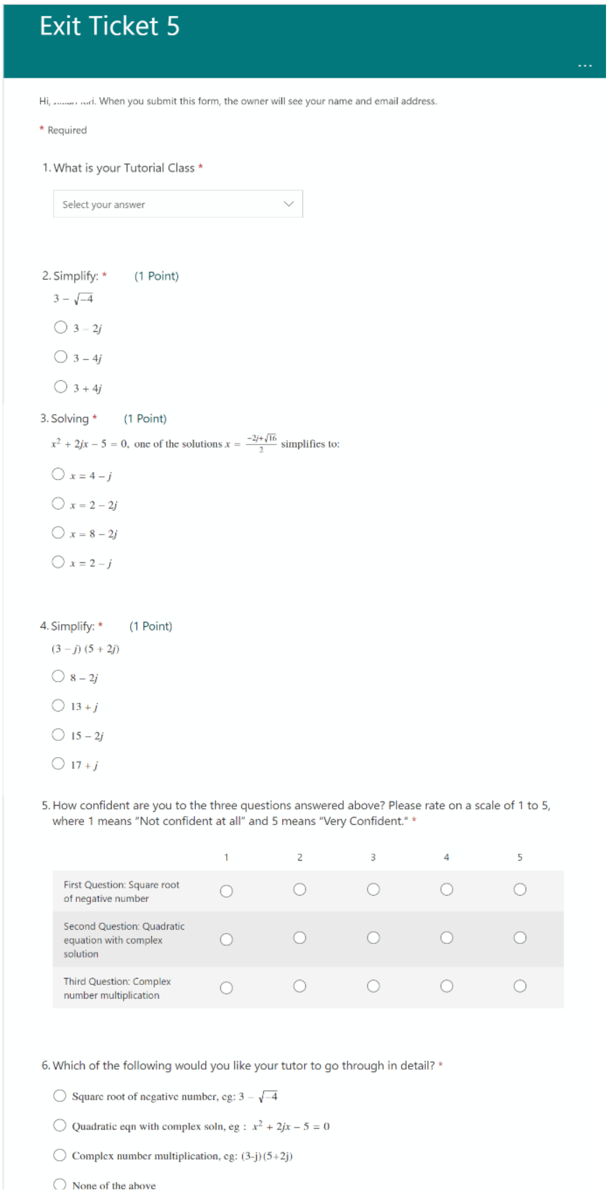
At the School of Engineering in Temasek Polytechnic, about 1200 – 1300 first year students taking the first course in Engineering Mathematics, Precalculus, fit the description of having diversified backgrounds with broad ranges of mathematics preparation and readiness. Despite the diverse preparedness of the students, they share the common goal of completing their diploma courses in good time. Coupled with this is the nature of the Precalculus module being a collection of varied topics in algebra, such that different students struggle with a variety of learning gaps along the way.

As with Dr. Maki, the subject team recognised the value in identifying students' learning obstacles in real time to bridge learning gaps there and then, rather than learning about students' learning gaps after major written tests at mid-semester and end of semester, when interventions are too late. Acquiring suitable assessment instruments that tutors could use to identify learning gaps during lesson time becomes important when carrying out suitable response strategies.

As students enrol into their first-year engineering diploma courses at Temasek Polytechnic, they are placed in different types of classes to better suit their learning needs, according to known learning backgrounds. About a quarter to a third of the cohort each year generally experience larger learning gaps and some are placed in Small Group Teaching (SGT) classes. These classes attend face-to-face two-hour lessons twice a week, where tutors teach the smaller tutorial groups and facilitate pen-and-paper problem-solving in class. The rest of the cohort are in non-SGT classes. They attend a hybrid of online and face-to-face lessons thrice a week, consist of a two-hour tutorial lesson, a one-hour tutorial lesson, and a one-hour large group lecture respectively. In this paper, we shall be referring to outcomes of students from SGT and non-SGT classes to observe differences, if any.

Assessment Instrument

A total of 8 Exit Tickets (ETs) at regular intervals spanning different topics were used as assessment instruments for student learning of Precalculus in the semester spanning April 2022 to September 2022. After the required topics were covered in class, students scan a QR code given by their tutor with their mobiles to access the relevant ET in the form of a Quiz in Microsoft Forms. Each ET (see Figure 1) consists of three carefully crafted assessment-like problems testing different concepts, three confidence-level survey questions for the problems, and a final survey question asking students to identify the topic they need more tutor-help in.


Exit Ticket 5

Hi, [illegible]. When you submit this form, the owner will see your name and email address.

* Required

1. What is your Tutorial Class *

Select your answer

2. Simplify: * (1 Point)

$3 - \sqrt{-4}$

- $3 - 2j$
- $3 - 4j$
- $3 + 4j$

3. Solving * (1 Point)

$x^2 + 2jx - 5 = 0$, one of the solutions $x = \frac{-2j+\sqrt{16}}{2}$ simplifies to:

- $x = 4 - j$
- $x = 2 - 2j$
- $x = 8 - 2j$
- $x = 2 - j$

4. Simplify: * (1 Point)

$(3 - j)(5 + 2j)$

- $8 - 2j$
- $13 + j$
- $15 - 2j$
- $17 + j$

5. How confident are you to the three questions answered above? Please rate on a scale of 1 to 5, where 1 means "Not confident at all" and 5 means "Very Confident." *

	1	2	3	4	5
First Question: Square root of negative number	○	○	○	○	○
Second Question: Quadratic equation with complex solution	○	○	○	○	○
Third Question: Complex number multiplication	○	○	○	○	○

6. Which of the following would you like your tutor to go through in detail? *

- Square root of negative number, eg: $3 - \sqrt{-4}$
- Quadratic eqn with complex soln, eg : $x^2 + 2jx - 5 = 0$
- Complex number multiplication, eg: (3-j)(5+2j)
- None of the above

Figure 1: Typical Exit Ticket (Exit Ticket 5 of 8)

In designing the ETs, the subject team used features deemed valuable by Eric Darsow (Darsow E. 2017-2020):

DESIGN FEATURES:

1. Assessment of learning should employ the least-invasive, least record-intensive strategies that are small, un-intimidating, and not framed as a ranking exercise.
    - The short questionnaires signal to students that feedback on their learning need is the key, not how well they perform on the questions. The tutor also models this attitude towards the ET through encouragement rather than ranking of students. Moreover, the shortness of the ET makes it least-invasive to the lesson and encourages higher adoption-rates in classes.

2. Assessment of learning should map real time assessment tools to lesson objectives, so that data and responses are coordinated around pre-determined learning outcomes.
    - The carefully crafted assessment-like problems give students an idea of similarly phrased questions in mid-semester and end-semester written tests. The concepts covered in all 8 ETs are related to lesson objectives comprising various concepts and skills.

3. Assessment of learning should plan real time assessment questions so that they are scaffolded and demand a range of intellectual rigour.
    - ETs are quick questionnaires comprising short questions on concepts, confidence levels and area of learning need, executed in real time after lesson delivery. To give breadth and depth to problems across all 8 ETs, basic to higher levels of understanding in concepts and applications are required, without the need for tedious computations.

Implementation

Implementing the ET is straightforward: at a suitable point in the lesson, the tutor reveals the QR code for students to scan and complete the relevant Exit Ticket. The ET inputs are captured by Power Automate (a software behind Microsoft Forms) and linked to a dashboard of Power BI. The tutor, seeing the data in real time, learns the profile of class, identifies which students are struggling and what concepts they are weak in, and adjusts the remaining lesson to cater to the class' need.

The implementation features regarded as vital by Eric Darsow (Darsow E. 2017-2020) were applied to ETs:

IMPLEMENTATION FEATURES:

1. Assessment of learning is best implemented when *decoupled from the stress of course letter grades.*
    - ETs are ungraded, formative assessments.

2. Assessment data is most meaningful when the *feedback comes as close to the actual practice process as possible*, using mini-assessment strategies *so that feedback comes fast.*
    - With Power Automate behind Microsoft Forms, data is instantly captured and displayed on the Power BI dashboard once students complete the Exit Ticket.

3. Learning involves lots of practice, and meaningful assessments *provide data to both the students about their own learning progress and data to the instructors as they plan and implement lessons*. It is good to transfer as much

of the assessment process to the learners themselves, empowering them to use that data for themselves, removing the teacher as an intermediary between students and their learning process.

- With the built-in response feature in Microsoft Forms, students can immediately know how they did on the problems and what the correct answers are upon completion of each ET. The reflection questions on confidence levels and area of need also help students understand their learning progress. In addition, they get help from the tutor who adjusts the lesson using data from the dashboard.

Dashboard

The dashboards were designed so that the tutor can see the results of students' individual ET at a glance (see Figure 2). The dashboards can be refreshed in real time or viewed from tabs on the subject's MS Team which were automatically refreshed hourly up to 8 times a day.

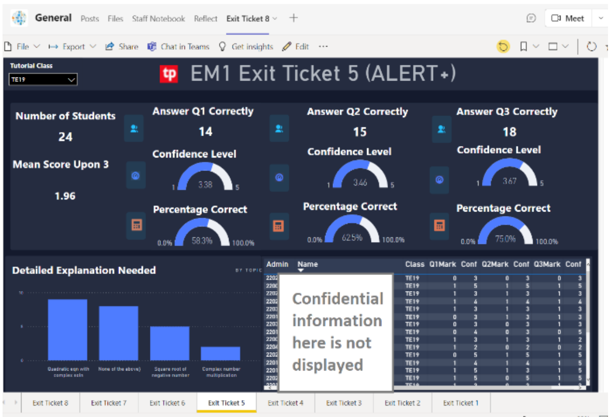


Figure 2: Typical Power BI dashboard for a tutorial class (for Exit Ticket 5 of 8)

All on one page with the option to sort by class, the tutor is able to view these items on a typical dashboard: number of students who responded, mean score of all three problems with a maximum of 3 points, mean confidence levels and percentage of students getting the problem correct by question (Figure 3), a chart displaying number of students requesting more detailed explanation from the tutor by topics (Figure 4), and input details of individual students who responded (Figure 5).

Since students log in using their school accounts, the system could accurately identify the student without additional questions. Students are inserted in the correct tutorial groups even if they input their tutorial class wrongly in the ET (first question in ET, see Figure 1).

The subject team is also able to access this data for the entire cohort afterwards for a better understanding of their learning profiles. This will be discussed under the section "Data and Observation" of this paper.

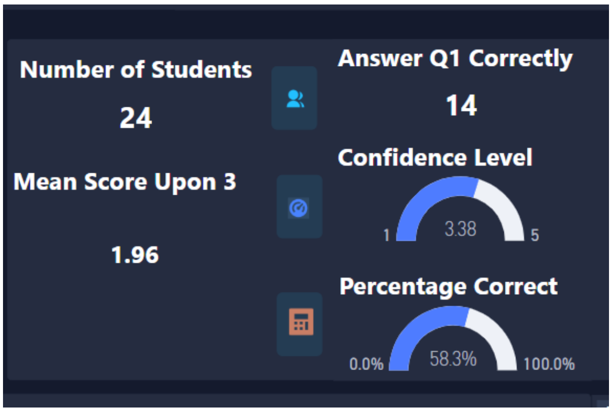


Figure 3: Close-up of Figure 2 showing Number of Students, Mean Score of ET, Breakdown of data for Q1

Figure 4: Close-up of Figure 2 showing number of students requesting more detailed explanation from the tutors by topics

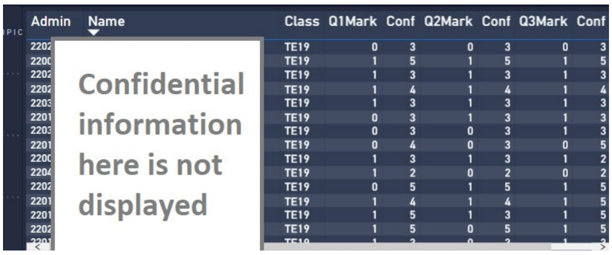


Figure 5: Close-up of Figure 2 showing details of individual student responses for the ET for relevant class

Response Strategies

Once the real time data is captured, three groups of people (see Figure 6) may give their response.

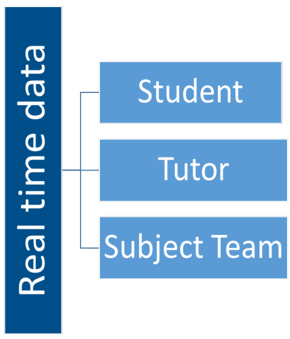


Figure 6: Real time data impacting responses of three groups of people

Students, realising the learning gaps they have, can consider different ways to close those gaps: checking with their peers, clarifying with their tutor, or practicing additional problems on relevant topics.

The tutor, knowing where the class now stands, can choose to review certain concepts again by demonstrating more examples or giving additional practice problems. He/she can also give targeted advice to individuals on what to work on. Figure 7 shows how the tutor can respond to individual students with:

a. High mean competency / high mean confidence for specific ET (top-right domain in Figure 7)
   - The student is getting the concepts right and confident. No action from the tutor is required since the student is performing well and confident.

b. High mean competency / low mean confidence for specific ET (top-left domain in Figure 7)
   - The student is getting the concepts right but is not confident. The tutor can build student confidence through encouragement and success in guided practice questions.

c. Low mean competency / low mean confidence for specific ET (bottom-left domain in Figure 7)
   - The student is getting the concepts wrong and also not confident. The tutor can explain the concepts in greater detail to student. Additional help is likely needed, so the subject team can filter these students out and recommend them to attend remedial lessons.

d. Low mean competency / high mean confidence for specific ET (bottom-right domain in Figure 7)
   - The student is getting the concepts wrong yet is confident. The tutor can clarify misconceptions of the student and encourage them to learn from their peers.

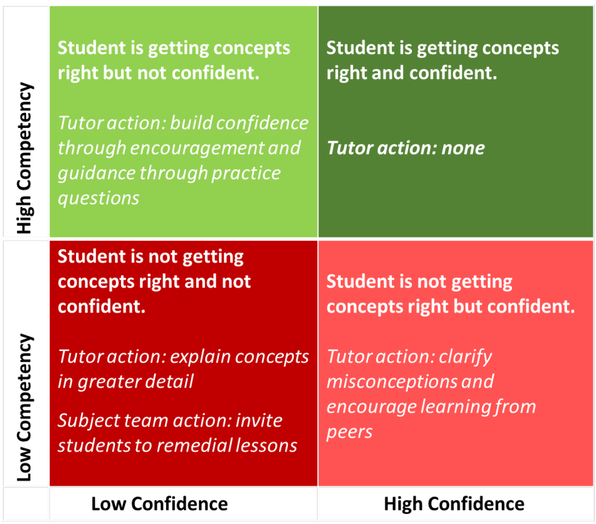


Figure 7: Possible profile of students with different competency and confidence levels, and possible response strategies.

Data and Observation

As we have seen, data from assessing student learning in real time has the advantage of providing students and tutors with immediate feedback close to their lesson activity. In addition, a deeper look at the overall data helps the subject team understand student learning profiles better as patterns are observed.

The ET data was collected for the April 2022 cohort of 1245 first year engineering students of Precalculus at Temasek Polytechnic. A few noteworthy observations are described below.

1. Participation rate

A high participation rate for ETs was observed in the earlier part of the semester (see Figure 8), which tapered off from ET5 onwards in the second half of the semester. Overall, participation rates varied between 48.9% to 88.8% per ET, with an average participation rate of 64.7% per ET. Given that it is the first time ETs are implemented in the module, this level of participation is reasonably good.

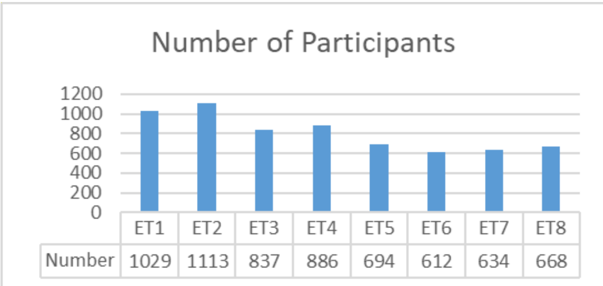


Figure 8: Number of participants for Exit Tickets.

In general, a higher participation rate (see Figure 9) was observed among students from non-SGT classes (67.1%) compared to students from SGT classes (48.8%). With generally larger learning gaps in SGT classes, tutors are likely to run out of lesson time for executing ETs, especially when students are struggling with more challenging topics in the second half of the semester.

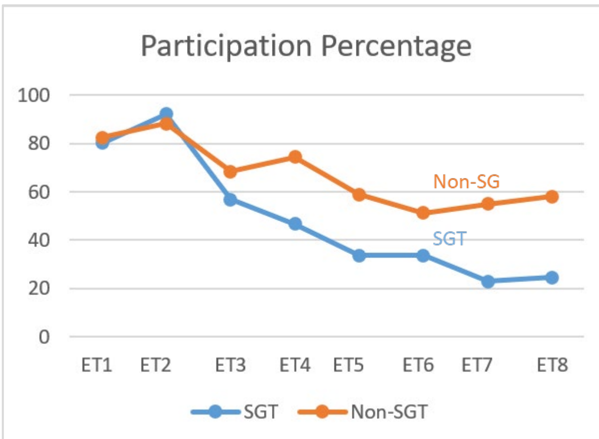


Figure 9: Percentage participation of SGT and non-SGT students.

2. Mean Score for Exit Tickets

With a maximum score of 3 points for each ET (1 point for each problem), mean scores for ETs are captured for the cohort (see Figure 10). With overall mean score at 2.35 upon 3, the ETs seemed to be pitched at appropriate levels of difficulty.

It was not surprising that harder topics (ET5 and ET7) recorded lower mean scores (< 2), while easier topics (ET1 and ET8) recorded higher mean scores (> 2.5).

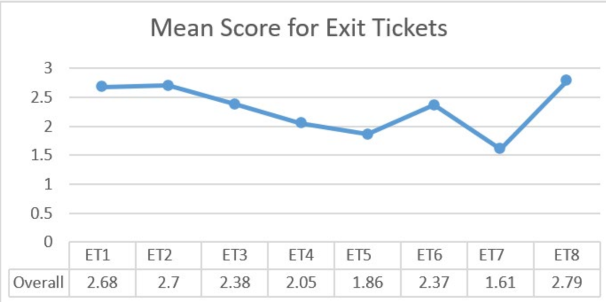


Figure 10: Mean score for Exit Tickets

Mean scores vary between non-SGT and SGT classes (see Figure 11). On the whole, the non-SGT classes consistently scored higher (mean of 2.37 with 95% confidence interval of [2.35. 2.39]) compared to SGT classes (mean of 1.79 with 95% confidence interval of [2.08, 2.23].

It seemed that both groups of students scored similarly well in easier topics (ET1 and ET8: without '*' means the difference is not statistically significant with $p > .001$), but the disparity becomes wide for harder topics (ET5 and ET7: with '*' means the difference is statistically significant with $p < .001$).

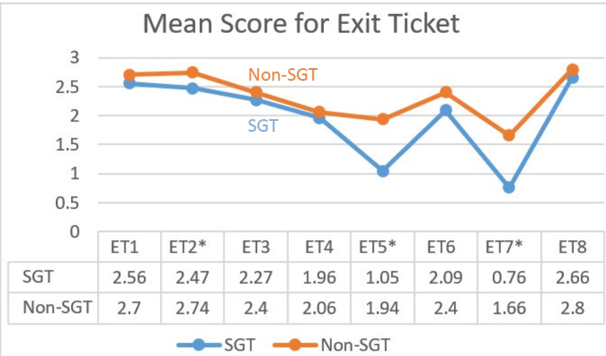


Figure 11: Mean score by Exit Ticket between SGT and non-SGT students.

Note: '' indicates t test significant difference for p < .001.*

3. Confidence level of students

As Figure 12 indicates, the mean (or average) confidence level of the students for in the Exit Ticket seemed to be roughly in step with the mean (or average) score by ET.

A strange phenomenon happens for ET6, however, as the mean confidence level seemed relatively low compared to their mean score. The reverse is true for ET5, where the mean confidence level increased even when the mean score dipped. These two topics covered concepts in Complex Numbers usually new to first year engineering students. This might have explained the irregularity since students were not confident about this topic.

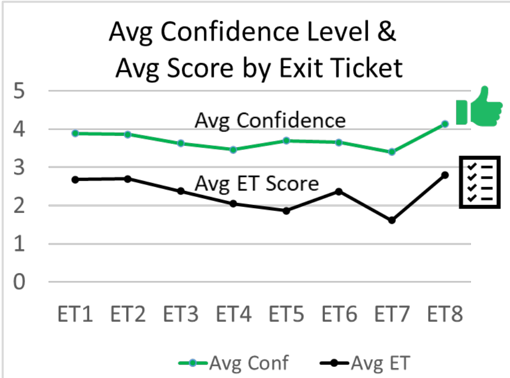
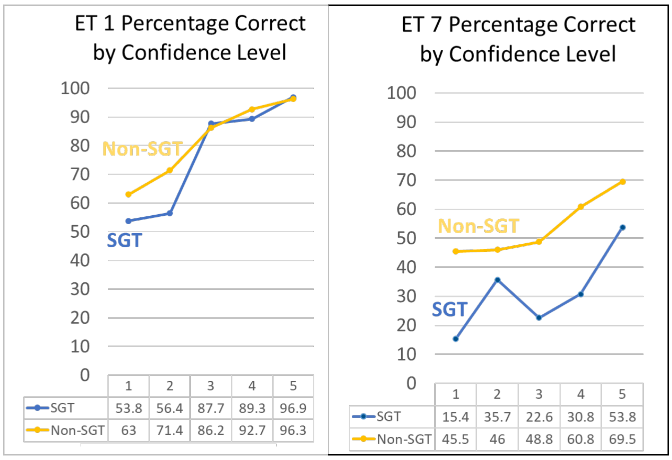


Figure 12: Average Confidence Level & Average Score of students by Exit Ticket

Figures 13a and 13b show how non-SGT and SGT classes fared for the same level of confidence level (horizontal axis). Higher percentages of students in non-SGT classes were getting the problems right for virtually all levels of confidence levels. The comparisons between ET1 (see Figure 13a on the left below) and ET7 (see Figure 13b on the right below) show that both groups fared similarly well when the topics are easier (ET1); but the gaps widen between the groups when the topics are harder (ET7). This indicates that confidence level do not always mirror competence, and students with wider learning gaps tend to misjudge their level of understanding when it comes to harder topics – a noteworthy point for tutors of SGT classes to know.



Figures 13a (left) and 13b (right):
Percentage correct by confidence level for ET1 (left) and ET7 (right) of SGT and non-SGT students.

4. No questions asked

The last question in each ET requires student to indicate which of the three topics (related to the three ET problems respectively) he/she would like the tutor to explain in greater depth. If student understood all three topics, he/she could select "none of the above" (see last question in Figure 1). Figure 14 below show the percentage of students who indicated "none of the above" because they had no questions to ask.

The figures seemed reasonable for ET7 and ET8 where lower percentages of students with "no questions to ask" tallied with the harder topics in ET7 and higher percentages tallied with the easier topics in ET8.

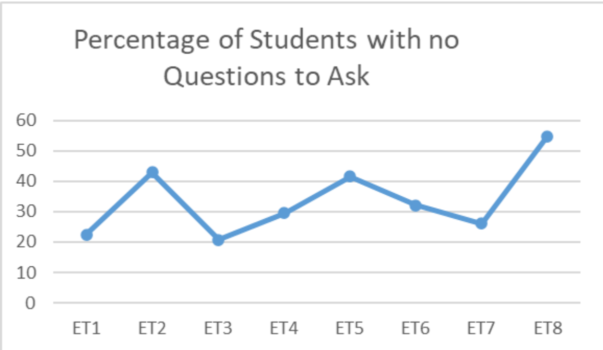


Figure 14: Number of students with no questions to ask by Exit Ticket.

Comparing with mean scores, different behaviours were observed, some expected (ET7, ET8), and others unexpected (ET1, ET5):

- ET1 recorded a high mean score but low percentages indicating "no questions to ask;
- ET5 recorded a low mean score but high percentages indicating "no questions to ask;
- ET7 recorded a low mean score and low percentages indicating "no questions to ask;
- ET8 recorded a high mean score and high percentages indicating "no questions to ask.

This seemed to indicate that regardless of the level of difficulty, students may have different reasons for indicating whether they had questions to ask.

5. Additional data from student/tutor surveys

Following the completion of the 8 Exit Tickets, feedback were collected from tutors and students who participated in the exercise, of which 16 tutors and 597 students responded.

The surveys consist of three Likert scale questions (ranging from 1 to 5 for strongly disagree, agree, neutral, agree, and strongly agree respectively) and one free response question. Table 1 shows the mean scores of the first three questions.

	The Exit Ticket was easy to implement.	The Exit Ticket helped me gauge student understanding.	The Exit Ticket gave me helpful feedback to pitch my teaching accordingly.
Tutor	4.25 upon 5	3.88 upon 5	3.69 upon 5
	The Exit Ticket was easy to use	The Exit Ticket was a useful check of my understanding.	The Exit Ticket was a good way to voice my doubts.
Student	4.46 upon 5	4.32 upon 5	4.25 upon 5

Table 1: Likert scale (1 to 5 for strongly disagree, agree, neutral, agree, and strongly agree respectively) scoring by 16 tutors and 597 students in similar surveys

Both tutors and students found the ETs easy to implement (4.25) and use (4.46) respectively. For the question of gauging (3.88) and checking (4.32) understanding, students were more satisfied with the effect of the ETs compared to tutors. When asked whether the ETs gave helpful feedback (3.69) and a good way to voice doubts (4.25), students again felt more certain compared to tutors. Students seemed slightly more optimistic about the effect of the ETs in helping them than tutors, though both groups agreed that ETs were easy to use.

Figure 15 shows the word cloud for student survey responses to the question "Share your thoughts with us e.g. how the Exit Ticket may be improved". Many students were happy with the use of the ETs as a way to check their learning progress. Some gave suggestions on putting tougher or more complex questions, while a small number preferred easier questions. A small number requested more questions to be posed per ET.

Tutors, on the other hand, did not comment much on improvements needed. Most were willing to try it and a few mentioned they needed time to familiarise themselves with the dashboard features.

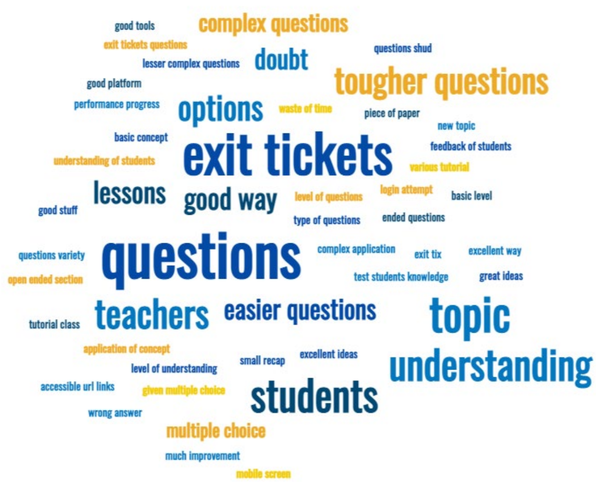


Figure 15: Word cloud for student survey responses to question "Share your thoughts with us e.g. how the Exit Ticket may be improved".

Final Remarks

The exercise of using Exit Tickets as instruments to assess student learning in real time for the April 2022 cohort of first year engineering students was a fruitful one.

Firstly, tutors and students found Exit Tickets easy to use. Mathematical problems coupled with confidence level questions and a query on learning need gave a more holistic picture of the student learning experience. The comprehensive one-page dashboard offered tutors a quick way to perceive the class' learning needs and carry out response strategies.

On the other hand, declining participation in the ETs as the semester progressed, especially for students in SGT classes, is informative. It seemed that some classes were time-tight in the second half of the semester, making it difficult for more students to use ETs. Given that students will only reap the benefits of ETs if they participate in them, increasing participation rates would be advantageous. This could mean adjustments to the work schedule by reducing ETs in the second half of the semester, allowing students to benefit from more unhurried class time without missing ETs.

The data helps the subject team understand students' learning profiles better. Students with larger learning gaps seemed to struggle much more in the harder topics even when they perceived they have understood them. It was also observed that confidence levels do not always reflect competency, and so verbal feedback from students in class might not reflect their true aptitude. Added to that, the apparent discrepancy of high percentages of students with no questions to ask while having low mean scores might mean: students did not know what to ask, or students were too tired to ask questions.

All in all, the venture to close learning gaps is an important one, because:
"… across those gaps faculty and other contributors to student learning miss opportunities to identify and address the kinds of struggles students face that lead to their underperformance, decision to drop out, or belief that they are not capable of succeeding. In a shared commitment to students' equitable achievement of outcomes, every student counts—not solely those who persist and are the subjects of periodic assessment." (Maki P. 2017)

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USING EDUTECH TOOLS TO SUPPORT HOME-BASED LEARNING THROUGH REPLICATION OF PHYSICAL CLASSROOM ACTIVITIES

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Abstract

The semester-long home-based learning (HBL) conducted in April to August 2020 has been deemed to be successful in Singapore Polytechnic as evidenced by a 5-polytechnic survey. Specifically, the end-semester HBL student survey conducted by the School of Mathematics and Science (MS) showed 93% of respondents agreed that synchronous sessions were effective for their learning. We hypothesize that the success of HBL is closely correlated to effective replication of the physical classroom activities to the online learning sphere. Hence, this study is aimed to verify this hypothesis, and investigate the EduTech tools used by lecturers to replicate the physical classroom activities in the online classroom during HBL, for the four domains in MS, namely Mathematics, Statistics and Analytics, Physics, and Infocomm Technology (IT) and Programming.

We conducted a lecturer survey for 58 lecturers, and 18 lecturers were subsequently interviewed for further insight. The end-semester HBL student survey results was also further analysed. From the data gathered, we collated lists of EduTech tools used by lecturers to replicate the physical classroom activities in different settings appropriate for each of the four domains in MS so as to maximize students' learning in the online learning sphere.

The findings from this study show that replicating the physical classroom activities with the appropriate EduTech tools contributed to a successful HBL which also enhanced student learning. The results also show that HBL is also successful among lecturers in terms of increasing their confidence in using EduTech tools.

Keywords: *Home-based learning, Online learning, EduTech tools, replicate physical classroom activities, synchronous lessons*

Introduction

In April 2020, due to the COVID-19 pandemic, Singapore went into lockdown, and physical lessons were suspended. In Singapore Polytechnic (SP), PCEO declared a semester-long home-based learning (HBL). Lecturers moved their lessons online and conducted them asynchronously or synchronously as appropriate. In the School of Mathematics and Science (MS), lecturers utilised EduTech tools to replicate physical classroom activities as far as possible in the online classroom.

To gauge the success of HBL, the Ministry of Education (MOE) conducted a 5-polytechnic survey. In this survey, 85% of SP respondents felt satisfied with or neutral towards their HBL learning experience. Quoting PCEO's email, "the responses from our students were very much positive and also in line with that of other polytechnics in general" (PCEO Soh Wai Wah, personal communication, 14 Dec, 2020). MS also conducted its own end-semester HBL student survey for MS modules. 93% of respondents agreed that synchronous sessions were effective for their learning. Thus, based on these surveys, HBL is deemed to be successful in teaching and learning, at nationwide level and in MS itself. However, to ensure MS' continual success in a future HBL, we need to first understand the factors that contributed to the success. Thus, in this study, we aim to investigate one such potential factor: the use of EduTech tools to replicate physical classroom activities in the online classroom.

Background

With the ubiquity of technology in today's interconnected world, it is pivotal for lecturers to understand the relationships between teaching, technology, and learning to promote student leaning, growth and achievement (Lei, Conway, & Zhao, 2008; Koehler, Mishra, Shin, & Graham, 2014). They will then be better equipped to select appropriate EduTech tools to bring about meaningful student learning (Hamilton, 2016; Goal of Technology Integrations: Meaningful Learning, 2013). Furthermore, technology is not only able to enhance learning, but also transform it. According to the Substitution Augmentation Modification Redefinition (SAMR) model illustrated in Figure 1 (Puentedura, 2013), technology transforms learning when it brings about significant task redesign or creates innovative tasks that were previously inconceivable.

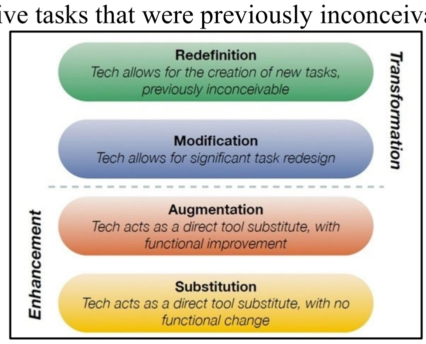


Figure 1:SAMR (Substitution Augmentation Modification

Redefinition) Model (Source: Puentedura, R. R. (2013). SAMR: Moving from enhancement to transformation.)

Thus, technology can generally have a positive impact on student learning. This is especially important for HBL, where *lecturers have to use technology in the form of EduTech tools, for both asynchronous and synchronous learning during HBL. Asynchronous learning refers to students learning at their own pace without real-time interaction with lecturers or other students (Synchronous Learning vs. Asynchronous Learning in Online Education, 2021). It typically occurs during the pre-class aspect of the physical classroom activities, where students may learn basic content in their own time*, with the given resources from lecturers. It can also occur post-class when lecturers follow up with students on their understanding in various ways such as assessments or consultations. On the other hand, synchronous learning occurs at set timings when lecturers and students come together to interact and learn (Synchronous Learning vs. Asynchronous Learning in Online Education, 2021). This is in place of the in-class aspect of the physical classroom activities where lecturers deepen students' understanding via quizzes, class engagement, feedback and peer learning.

Research Questions

In this study, we aim to answer the main research question "Does using EduTech tools to replicate the physical classroom activities in the online classroom contribute to the success of HBL in MS?"

This is further subdivided into secondary research questions covering lecturers' and students' point of view:

(RQ1) What are the required EduTech tools for lecturers to replicate the physical classroom activities in the online classroom during HBL, for the four domains in MS, namely Mathematics, Statistics and Analytics, Physics, and Infocomm Technology (IT) and Programming?

(RQ2) Does replicating the physical classroom activities with the appropriate EduTech tools enhance student learning?

(RQ3) Is HBL successful for lecturers in terms of increasing lecturers' confidence in using EduTech tools?

We hypothesize that lecturers who closely replicate physical classroom activities with EduTech tools will enhance student learning, and that HBL is largely successful for lecturers in terms of increasing their confidence in using EduTech tools.

Methods

To test our hypothesis, we used various research instruments. We conducted a survey and interview to collect data from lecturers on the EduTech tools they used as well as their confidence level in using EduTech tools. We also analysed the results from MS' end-semester HBL student survey to investigate the success of HBL from students' perspective. Table 1 summarises the various research instruments and data collected.

Table 1: Summary of Research Instruments and Data Collected

Research Instruments	Lecturer Survey	Lecturer Interview	Student Survey
Assessment questions	Structured (5 Questions)	Semi- structured	Structured (6 Questions)
Mode of deployment	Online survey via Microsoft Forms	Online via Microsoft Teams/ Face to Face interview	Online survey via Microsoft Forms
Administration of research instrument	Non-anonymous	Non-anonymous; shortlisted based on lecturer survey	Anonymous; one survey for each of 48 modules
Purpose	Collect data on EduTech tools used by lecturers and their confidence level in using EduTech tools		Collect data to gauge the success of HBL from students' perspective
Number of target participants	95	18	7673
Number of responses (Response rate)	58 (61%)	18 (100%)	4542 (60%)

Lecturer Survey

We carried out the lecturer survey online from 25th Sep to 9th Oct 2020 for all MS lecturers who taught during the HBL semester. 58 lecturers, full-time and adjunct, submitted their response (61%).

In the lecturer survey, respondents indicated the domain of the MS modules they had taught during the HBL semester. They also selected and listed the EduTech tools they had used during HBL. In addition, they indicated their confidence level in using EduTech tools before and after HBL, via a five-point Likert Scale ranging from 1 "No confidence" to 5 "Very Confident". A snapshot of the survey is shown in Figure 2.

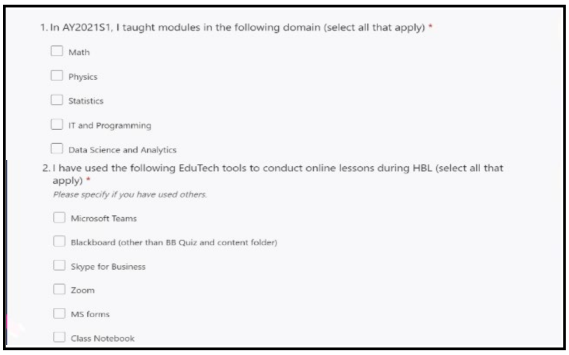


Figure 2: Snapshot of lecturer survey

Lecturer Interview

After consolidating the survey results, we invited 18 lecturers for an interview. The lecturers were shortlisted based on their survey response about the EduTech tools they used. Those who had very high or low confidence in using EduTech tools before the start of HBL were

shortlisted as well. In addition, we ensured that the shortlisted lecturers spanned the four MS domains. The interviews were carried out over three weeks, 26th Oct to 13th Nov 2020, either online over Microsoft Teams or face-to-face.

In the lecturer interview, interviewees were asked to elaborate on their survey responses. They provided more detailed information about the EduTech tools they used and their survey responses.

Student Survey

We also obtained data from the end-semester HBL student survey, earlier conducted by MS from 12th to 21st Aug 2020. There was one survey for each of MS' 48 modules offered. The survey was kept anonymous but students were asked to indicate their respective module class. A total of 4542 responses were received (60% response rate).

For the purposes of our study, we analysed the results from the relevant questions, which are Question 2 (Q2) and Question 3 (Q3). Q2 asked students to rate how effective their synchronous live sessions were on a six-point Likert Scale, ranging from 1 "Completely Disagree" to 6 "Completely Agree". Q3 asked students to choose areas that supported their HBL well. In this study, we are interested in whether students selected the following areas:

- Interactive, engaging online learning materials
- Sufficient online learning activities (e.g. quizzes, group discussions, tasks) to help me understand my lessons better
- Sufficient opportunities to interact with peers and lecturer online

Results

Student Survey Analysis

Based on the lecturer survey, we observed that lecturers fall into two broad categories: 1) Group A: lecturers who used mainly Microsoft Teams, and 2) Group B: lecturers who used Microsoft Teams and a few other EduTech tools. Thus, we analysed the end-semester HBL student survey for these two groups of lecturers.

Based on the responses to Q2 of the student survey, we see from Figure 3 that a higher percentage of 79.3% of students strongly agree or agree that Group B lecturers' synchronous live sessions are effective. This is in contrast to 66.8% for Group A lecturers.

In addition, based on responses to Q3 (Figure 4), a higher percentage of students selected that Group B lecturers had provided them with engaging online materials (50.2% for Group B in contrast to 40.3% for Group A), engaging online activities (44.1% for Group B in contrast to 35.1% for Group A), and provided sufficient opportunities to interact with peers and lecturer online (29.0% for Group B in contrast to 22.8% for Group A).

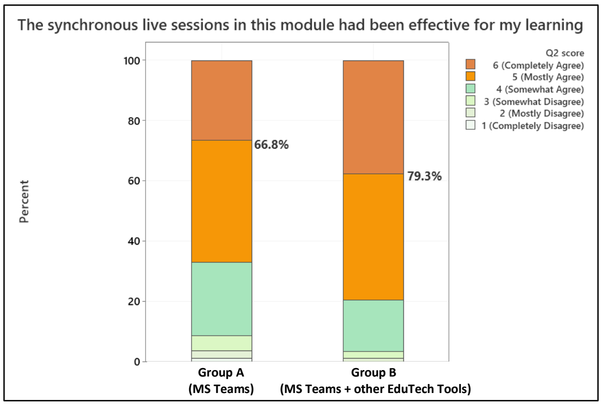


Figure 3: Comparison of effectiveness of synchronous live sessions

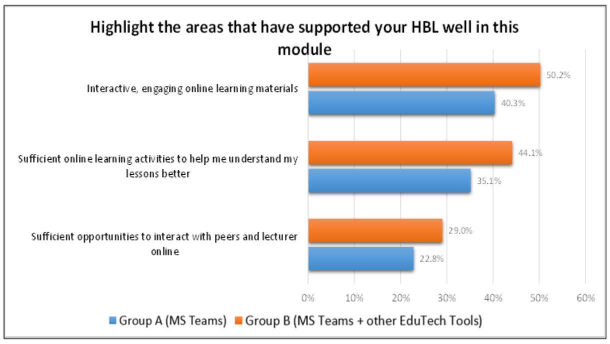


Figure 4: Percentage of students who selected the areas as having supported their HBL well

Lecturer Confidence Level Analysis

In the lecturer survey, lecturers rated their confidence level in using EduTech tools before and after HBL, ranging from 1 "No Confidence" to 5 "Very Confident". Before HBL, 22.4% had confidence levels of 4 and 5. After HBL, this rose sharply to 91.4% of lecturers with a confidence level of 4 and 5. Figure 5 shows that all lecturers either maintained their status quo confidence level from before HBL or an increased level confidence after HBL. 81% of the lecturers surveyed increased by at least one confidence level.

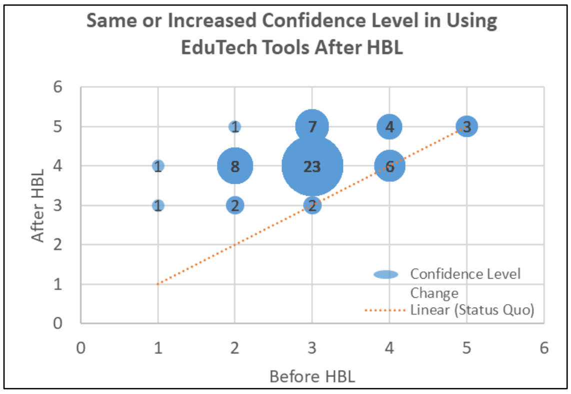


Figure 5: Change in lecturers' confidence level in using EduTech tools before and after HBL. The number of lecturers are indicated in each bubble.

Discussions

Replicating Physical Classroom Activities Engagement in the Online Classroom with EduTech Tools

In a physical classroom activities, engagement can be broken down into 8 typical types: "Lecturer ask Question", "Student answer Question", "Student ask Question", " Lecturer Answer Question", "Student talk to Student", "Student present to Students", " Lecturer write Students observe", and "Students write Lecturer observe". Based on the lecturer interview and survey, we investigated and matched the EduTech tools to their capability to replicate these physical classroom activities. We also broadly categorised the type of EduTech into versatile types (yellow colour), live responses types (blue colour) and writing types (green colour). Our findings are tabulated in Table 2.

A key EduTech tool to highlight is Microsoft Teams, as it is an essential and highly versatile tool. It is able to facilitate two-way engagement during the synchronous learning sessions where students and lecturers can interact with each other. Microsoft Teams also facilitates collaboration as lecturers can create channels for group discussion, where students can present and communicate with each other. The only missing engagement aspects are “Lecturer write Students observe” and “Students write Lecturer observe”. These thus need to be supplemented by other EduTech tools such as Whiteboard.fi which can facilitate such engagement.

Replicating Physical Classroom Activities in the Four Domains

Based on the lecturer survey and interview, and our discussion on which EduTech tools replicate which types of physical classroom interactions, we analysed the characteristics of the four different domains in MS. We then consolidated the required EduTech tools for an effective synchronous session to address RQ1.

Figure 6 illustrated the physical classroom activities vs comparisons across the four main teaching domains in MS. IT and Programming domain has the closest similarity with its physical classroom counterpart, followed by Statistics and Analytics, Mathematics and finally Physics which has the least similarity.

IT and Programming Domain

The similarity is deemed to be the highest for the IT and Programming domain due to its predominant use of computers for such software-intensive modules in the physical and online classroom. In the physical classroom, while lecturers demonstrate and explain the steps, students will follow them on the projector. This has close proximity to the online classroom. A challenge for this online classroom is that students who have only one computer screen need to toggle between looking at the lecturer’s demonstration and executing it on their laptop.

Thus, it is recommended for students to have a dual screen. The dual screen could take the form of another computer/laptop, a monitor, a tablet or a mobile. If it is not possible, other alternatives would be getting the student to do a split screen on their laptop or even printing out the course notes with the instructions or guide.

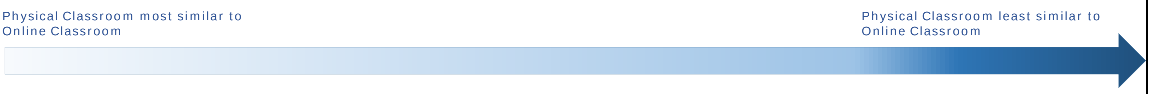
Statistics and Analytics Domain

For the Statistics and Analytics Domain, the modules are usually both software and concepts intensive. Lecturers would need to demonstrate how to use the statistical or analytics software, explain and illustrate concepts by drawing out diagrams (e.g. the normal distribution curve), or write out some pertinent formulas.

Table 2: List of EduTech Tools for engaging students

List of Engagement Tools (Synchronous lesson)	Lecturer ask Question	Student answer Question	Student ask Question	Lecturer answer Question	Student talk to Student	Student present to Students	Lecturer write Students observe	Students write Lecturer observe
Microsoft Teams	✓	✓	✓	✓	✓	✓		
Padlet	✓	✓				✓		✓
Classpoint	✓	✓				✓		
Kahoot	✓	✓						
Quizzlet	✓	✓						
MS forms	✓	✓						
Polly	✓	✓						
Miro (Aww whiteboard)						✓	✓	✓
Microsoft Whiteboard						✓	✓	✓
Whiteboard.fi						✓	✓	✓
Class Notebook							✓	✓
*Writing tool (e.g. stylus)							✓	
Notability (on iPad)							✓	
Zoomit							✓	

Versatile Types | Live response Types | Writing Types



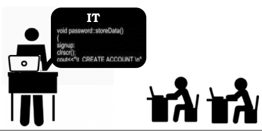
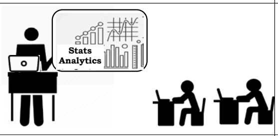
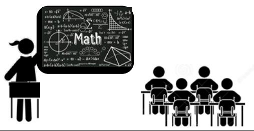
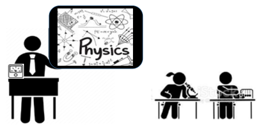
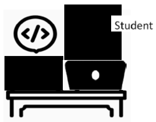
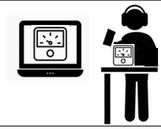
Domain	Infocomm Technology (IT)	Statistics and Analytics	Mathematics	Physics
Characteristics	Software-intensive	Software + concepts intensive	Concepts + Formula intensive	Concepts and Formula + Lab and Demonstration intensive
Physical Classroom				
	Lecturer demonstrates and explains steps using laptop via projector, and students learn the relevant functions and commands using the appropriate software. Lecturer troubleshoots any errors on students laptop.	Software: Lecturer demonstrate steps using laptop via projector and students follow on their laptop. Lecturer troubleshoots any errors on students laptop. Concepts: Lecturer explains concepts using whiteboard/projector,students do tutorials and lecturer observe to check their understanding.	Lecturer explains concepts using whiteboard/projector. Lecturer clarified doubts or questions from students using some mathematical formulas, with extensive writing and explanation on whiteboard/projector. Students do tutorials and lecturer observe and check for their understanding.	Lecturer explains concepts using whiteboard/projector, coupled with demostrations using online sources or physical objects. Students run experiments to further explore concepts in the laboratory with lecturer guidance. Students do tutorials and lecturer observe and check for their understanding.
Online Classroom (synchronous session)				
	Lecturer demonstrates steps online using laptop. With dual screen (mobile devices, split window of laptop), students learn the relevant functions and commands through hands-on-activities using the respective software. Lecturer troubleshoots any error when students share their screen online.	Software: Lecturer demonstrates steps online using laptop. Students follow on their laptop using dual screen (mobile devices, split window of laptop). Lecturer troubleshoots any error when students share their screen online.	Lecturer explains concepts online using laptop with stylus pen and clarified doubts or questions from students. Student do tutorials with the absence of lecturer's supervision.	Lecturer explains concepts online using laptop, coupled with demostrations using online sources or physical objects (with the help of wireless headset). Student do tutorials with the absence of lecturer's supervision. No experiment in laboratory.
Recommended EduTech tools	MS Teams + Dual Screen (Students)	MS Teams + Dual Screen (Students) + Writing Tools	MS Teams + Writing Tools + Whiteboard .fi	MS Teams + Wireless headset (Teacher)

Figure 6: Replicating physical classroom activities in the four domains

Thus, it is recommended for lecturers to use Microsoft Teams and have necessary writing tools to write digitally during online lesson. Similar to IT and Programming domain, students are recommended to have a dual screen to follow the software demonstration.

Mathematics Domain

For the Mathematics domain, the similarity between physical classroom activities and online classroom is not high as there is much writing on the whiteboard in the physical classroom to explain concepts. Lecturers would also get students to present their solutions on the whiteboard to show their understanding. Lecturers would also usually walk around the class to check on student understanding as they attempt tutorials questions. In the online classroom, lecturers can use a stylus pen to write on their screen. However, lecturers will have difficulty monitoring student understanding in real-time.

To bridge this gap, it is recommended to use an additional EduTech tool like Whiteboard.fi which enables students to write down solutions. The collaboration space encourages students to work together as the lecturer provides real-time feedback and immediate overview over the students.

Physics Domain

The similarity between physical classroom activities and online classroom is considered to be the lowest for Physics domain as there are usually laboratory and demonstration sessions involved other than usual lectures and tutorials. To replace physical demonstrations during HBL, most staff interviewed who teach Physics have turned to virtual demonstrations using YouTube videos, or other platforms like Mastering Physics and Learning Catalytics. However, there can be limitations, and some of the materials may not be able to fully achieve the intended course objectives.

Thus, to supplement these online materials, lecturers could further facilitate student learning by replicating the physical laboratory activity through some form of physical demonstration in a synchronous online classroom. To do so, it is recommended for them to get a wireless headset with microphone features to use as it will allow lecturers to have ease of movement while conducting the demonstration and communicating with students at a distance away from the computer.

Increasing Engagement Across the Four Domains

From the student survey results shown in Figure 4, Group B lecturers who used additional EduTech tools coupled with Microsoft Teams appeared to replicate the physical classroom activities in a better way, with improved interaction and engagement with students. This addresses RQ2. A list of the additional EduTech tools and their various categories are tabulated in Table 2.

HBL Success in Increasing Lecturers' Confidence in Using EduTech Tools

In the lecturer survey, there were positive results regarding lecturers' confidence level in using EduTech tools. 91.4% had a confidence level of 4 and 5 after HBL, and this was mostly due to an increase in confidence levels from before HBL where only 22.4% had such confidence. The low ratings for before HBL were despite

the fact that previous semesters had a HBL-week that was supposed to prepare lecturers for the semester-long HBL scenario. Quoting two interviewed lecturers, this could be due to HBL-week having "too short a timeframe to incentivise lecturers to experiment with or practise using EduTech tools" and some lecturers "might not even include synchronous learning". As such, many lecturers may not have been familiar with EduTech tools and therefore were not confident in using them.

However, after HBL, many lecturers' confidence level rose, and 81% of them rose by at least one level. This subsequent rise after HBL is thus likely due to lecturers being forced to use EduTech tools to replicate the physical classroom activities during HBL for both asynchronous and synchronous learning. These results show that a longer timeframe of hands-on use may be necessary in preparing lecturers for a potential HBL semester. These results also show that HBL is successful among the lecturers in terms of increasing their confidence in using EduTech tools. This answers RQ3.

Limitations and Future Work

Due to the response rate of the lecturer survey (61%) and the time constraint, we only managed to interview 18 staff among MS (19% of MS staff strength). This could have limited our findings. Another limitation is that the recommended EduTech tools may be specific to the context of the teaching domains in MS. For example, the IT and Programming domain in MS is about teaching students software. In other contexts, the IT and Programming domain may include IT modules such as Internet of Things (IoT) which involve the use of hardware like physical sensors and objects.

Moving forward, lecturers can also think about how some EduTech tools used during the HBL semester can also be appropriate for physical classroom activities during normal semesters. For example, these EduTech tools could to enhance learning by increasing student collaboration, or to even expose students to the outside world. In addition, lecturers can research how to use appropriate EduTech tools to reach the higher categories of the SAMR model of augmenting (Category 2), modifying (Category 3) and redefining (Category 4) learning (Hamilton, 2016).

Conclusions

In this paper, we have shown the use of various appropriate EduTech tools to closely replicate the physical classroom activities contributed to the success of HBL to a large extent for the four domains in MS, namely Mathematics, Statistics and Analytics, Physics, and IT and Programming.

Microsoft Teams was recommended to all lecturers in MS to conduct lessons online and it proved to be an essential and versatile EduTech tool for lecturers to replicate most activities that happen in the physical classroom activities for all four domains in MS. However, there are other live response and writing types of EduTech tools which could complement Microsoft Teams in replicating the physical classroom activities more successfully for each specific domain in MS. Student survey showed that lecturers who used additional appropriate EduTech tools coupled with Microsoft Teams to replicate the physical classroom activities, had led to enhanced student learning, improved interaction and engagement. Furthermore, after the HBL semester which allowed sufficient time for lecturers to hone their skills in using EduTech tools, a great majority (81%) of MS lecturers surveyed showed an increase in confidence level when using EduTech tools. In conclusion, we are confident that MS lecturers will be able to conduct successful HBL sessions in the future with their experiences gained in using EduTech tools, as well as utilise appropriate EduTech tools in their physical classroom to transform learning.

Acknowledgements

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Development of VR & PC laboratories – STEM Enhancement

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Abstract

Recently, STEM education is being promoted in Hong Kong as it is essential for students' lifelong learning and whole-person development. Apart from cultivating students' interest in Science, Technology and Mathematics, it also aims to strengthen students' ability to integrate and apply knowledge and practical skills across different STEM disciplines.
In this project, both Virtual Reality (VR) and Personal computer (PC) version laboratories were developed by integrating Science and Technology in order to facilitate the students in practicing the experimental procedures in a safe manner with immersive virtual environment even outside the laboratory and school. Hence, there is no time and place limitation. In addition, it inspires their interests in the area of experiment through the approach of digitalization and curriculum enhancement.

Keywords: *chemistry, digitalization, science, STEM, technology, titration, virtual reality, VR*

Introduction

STEM is an acronym that refers to Science, Technology, Engineering and Mathematics. (Brenda and Celestine, 2014; Buckner and Boyd, 2015) In the 21st century, it is a challenge to promote STEM education in order to align with the worldwide education trend and equip students to meet the rapid scientific and technological change around the world. (Education Bureau of Government of HKSAR, 2016)

In 2015, the Government of the HKSAR first proposed the promotion of STEM education in Policy Address, and further supported in the 2016. (The Government of the HKSAR, 2015; The Government of the HKSAR, 2016) It should be noted that with STEM education being highlighted as a curriculum emphasis, VTC STEM Education Centre is proactive in implementing STEM education in different campus of Hong Kong Institute of Vocational Education.

At this time, by combining different elements in STEM, a virtual laboratory was developed in order to inspire students' interests in the area of chemistry and experiment through the approach of "Playing game"

Results and Discussion

A VR/PC "Virtual Laboratory – Titration Experiment" was designed in order to enhance the students in studying and understanding one of the most fundamental chemistry experiments, Acid-base titration, in an interactive way or "Game Playing" alongside with supplementary teaching materials, information on the experiments and laboratory safety, other than reading textbook or watching the reference videos traditionally.

When start to "play" or run the Virtual Laboratory, students are first guided to choose proper personal protective equipment, such as safety goggles, laboratory coat and gloves, before starting of the experiment in order to deliver the message of "Safety is number one priority". Personal protective equipment is important because it prepares you for any safety risks and health, and gives you extra protection even there is an accident in the laboratory. Students should "Gear up" a set of proper personal protective equipment at the beginning, otherwise they can't start to play the virtual laboratory. (Figure 1)

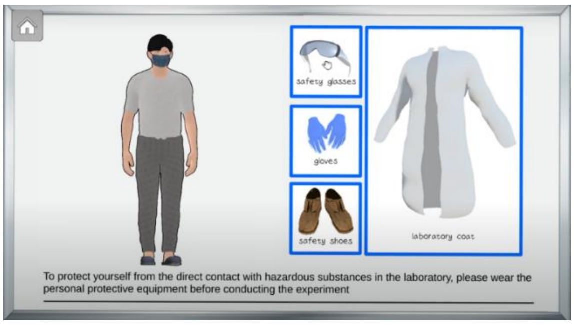

Figure 1 "Gear up" before starting the experiment

Inside the virial laboratory, students will have a pair of simulated hands and be in a simulated laboratory environment. (Figure 2) They can touch, hold and

control the apparatus or equipment by using a VR controller.

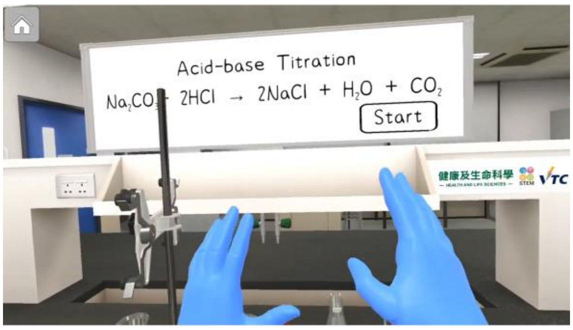

Figure 2 A pair of simulated hands and a simulated laboratory environment.

During playing the virtual laboratory, a clear "step-by-step" procedure will be displayed on the whiteboard with voice navigation. Students can follow the step clearly with no doubt. Notably, the next step of procedure will only appear when students complete every single step correctly. (Figure 3)

Figure 3 "Step-by-step" on whiteboard with voice navigation.

Some essential practical skills, such as how to observe the reading of burette, are included in the virtual laboratory. (Figure 4) In addition, students can even control the speed of addition of titrant from the burette (Figure 5) and observe the colour change of the titration clearly and easily. (Figure 6) In such approaches, students do not have to be afraid of doing wrong steps and wasting the chemicals or materials. Students can attempt to do the virtual experiment as many times as they want without time, materials and place limitation

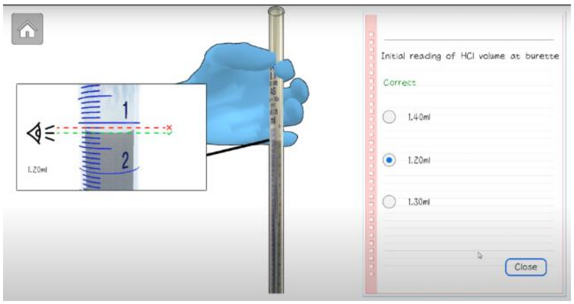

Figure 4 Skill of observing the reading

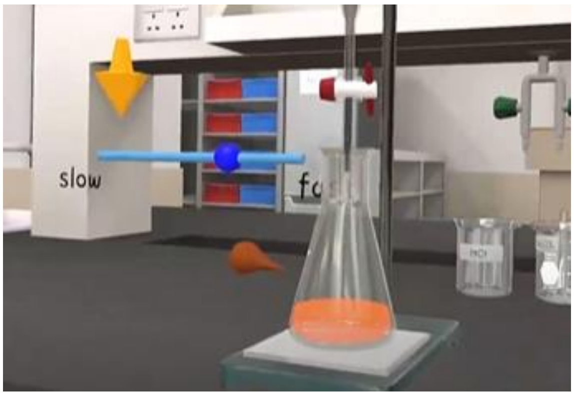

Figure 5 Controlling the speed of addition of titrant from burette

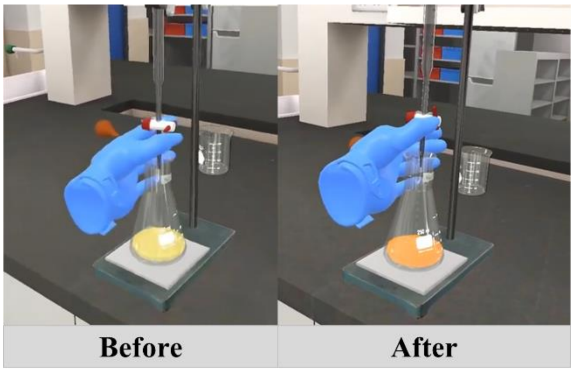

Figure 6 Easy and clear observation of the colour change

At the end of the virtual laboratory, a logbook for recording experimental data and simple calculation for teaching the students how to find the molarity of target solution will also be provided. (Figure 7) Students can acquire both practical skills and ability in calculation via playing the virtual laboratory.

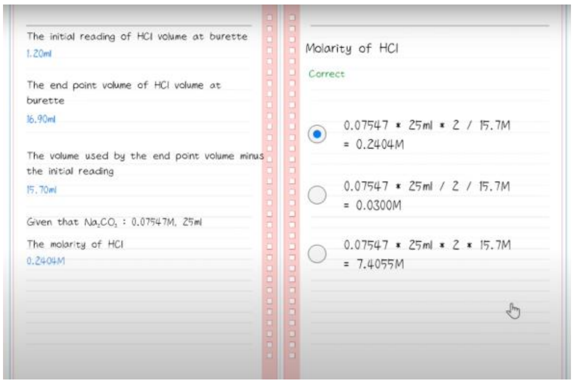

Figure 7 A logbook for recording experimental data and simple calculation step

One completion of "Playing the VR game", students are able to 1) recognize the safety and environmental compliance in laboratory; 2) handle and operate different types of analytical laboratory apparatus for scientific experiments; and 3) analyse and present data obtained from experiments.

Conclusions

In the immersive virtual laboratory, students can perform the experiment without any laboratory risk, such as hazardous chemicals or breakage of glassware. Noteworthy that basic laboratory techniques are also covered, students can practice and acquire those techniques and skills prior going to the real laboratory without time, materials and place limitation. We anticipate that this interesting development will provide an alternative direction of future laboratory teaching.

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Improving Disaster Prevention Awareness through Interdisciplinary Team building and Project-based Education

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Abstract

In recent years, there has been an increase in natural disasters worldwide, affecting the lives of many. Japan's topography is prone to natural disasters, and the country has experienced extensive damage from large-scale earthquakes and tsunamis in the past. Large-scale earthquakes affecting vast areas are expected to occur in the future; thus, it is necessary to raise public awareness about disaster prevention. Our college provides practical training courses to enable fourth-year students to develop experiential and participative learning abilities, find and solve problems, and communicate through presentations. Three to five faculty members across different fields supervise the eleven themes in this course. Students contribute to their inter-disciplinary teams by learning activities, understanding their roles, and developing creative proposals through teamwork. The course was designed to include seven practical items to improve student disaster prevention awareness in the Kushiro area, which is prone to natural disasters like large-scale earthquakes, tsunamis, snow damage, and volcanic eruptions. These practical items include disaster literacy, writing a disaster prevention novel, thinking about power generation, making a cardboard bed, making disaster prevention items, playing an evacuation shelter management (HUG) game, and experiencing life in an evacuation shelter. Additionally, the course was planned across 32 sessions, each of 180 minutes and involved five participating teams, each with three students. All five group portfolios confirmed the importance of disaster awareness. Each student was asked to rate the achievement level of the team project on a 5-point scale from 0 to 4 for ten items regarding self-assessment and peer assessment. The average achievement scores of the 15 students were recorded to be 3.72 for self-assessment and 3.91 for peer assessment. A student commented that writing a disaster prevention novel after the HUG game would help write a story. It is necessary to consider the order of these practical items in the future. We implement the designed practical items for 15 students, analyze student portfolios on both quantitative and qualitative aspects and report on the contribution of this exercise to the overall problem-solving skills of the team and the students' awareness of disaster prevention.

Keywords: *disaster preparedness education, disaster literacy, cardboard bed, a disaster prevention novel, evacuation shelter management game*

Introduction

The Cabinet Office of the Government of Japan is working to promote an understanding and awareness of disaster reduction. Globally, disaster reduction education is linked to the education of contemporary issues such as Education for Sustainable Development and the Sustainable Development Goals (SDGs) (Sakaue, 2019). In engineering education, interdisciplinary projects are popular to foster creativity. Tzanova (2018) stated that interdisciplinary education develops the competencies of engineering students. Pourshairif et al. (2018) also note that one of the elements of transformative education for the SDGs is interdisciplinary teamwork to share expertise and engineering skills and achieve project deliverables.

The National Institute of Technology, Kushiro College has been offering a practical training course to fourth-year students. In this course, students are expected to contribute to interdisciplinary teams by learning activities, understanding their roles, and developing creative proposals through teamwork.

The authors are in charge of one such class working on the theme of disaster prevention.

Japan is an earthquake-prone country. In particular, East Hokkaido, where Kushiro is located, has been hit by large-scale earthquakes every 500 years and another large-scale earthquake is expected in the near future. Since our college is located in the waterfront area of Kushiro, tsunami poses a great threat. Other problems unique to the northern regions include snow damage and extreme cold in the event of a disaster.

In the class, students should assume that they would be affected by these disasters and think about the impact and ways of survival. One of the goals of this class is to improve students' disaster prevention awareness, which would be useful to survive expected disasters.

This class includes seven practical items: disaster literacy, writing a disaster prevention novel, thinking about power generation, production of cardboard beds, playing an evacuation shelter management (HUG) game, evacuation shelter experience, and disaster prevention goods production. The next section details each item.

The course is planned across 30 sessions, each of 180 min, with five participating teams, each with three students. Some of the seven items are addressed individually while the rest are addressed as a group. Grading is based on self-assessment, using reflection sheets, and peer assessment. The details are provided in the Lesson and Evaluation Methods section.

We analyze these reflection sheets on quantitative and qualitative aspects and report on the contribution of this exercise to the overall problem-solving skills of the team and the students' awareness of disaster prevention.

Practical Items

In this section, we explain the seven practical items (A-G) of this class.

A. Disaster Literacy

The class begin with an introductory lecture on disaster literacy to provide general knowledge about disasters.

In this lecture, we explain the earthquakes and tsunamis that occurred in Japan in recent years and explain the expected damages when a similar disaster recurs. It also provides an opportunity to think about the importance of daily preparedness, using the "Disaster Prevention at Home" workbook[1].

We emphasize the importance of preparation to reduce the damage caused by disasters.

B. Writing a Disaster Prevention Novel

The purpose of this program is to reconfirm students' disaster awareness by writing a novel about a disaster, its consequences, and the actions they would take. Through this program, students would reveal and organize their latent disaster awareness and preparedness. The requirements for writing this novel are as follows:

1. A huge earthquake (M7) and an ensuing tsunami occurred in late September.
2. Infrastructure, such as electricity, gas, and water supply, were lost from the time of the disaster.
3. The number of COVID-19 cases is increasing and influenza is beginning to spread in the schools.
4. The novel begins with an early warning announcement of an earthquake.
5. Create a story based on the assumption that you will spend three days in a shelter.
6. The novel must have a happy ending.

Students can envision the disaster situation, based on their previous experience and knowledge, and organize their actions accordingly. We believe that disaster prevention novels, based on students' living environment, lead to appropriate behavior patterns during an actual disaster.

The novels are presented by all the members, allowing each member to their recognition of disaster situation assumptions and awareness, leading to increased disaster awareness learning.

In addition, the study by Oki et al. (2018) indicates that, beyond disaster prevention education, education through disaster prevention novels contributes to students' self-realization and leads the entire community, to an ideal state of disaster preparedness.

C. Thinking About Power Generation

Electricity is crucial and indispensable in daily life. However, disasters destroy power grids and cause outages. Other resources, such as gas and water, also require electricity. When power outages occur, all services are halted. The restoration of these lifelines takes time. In the Great Hanshin Earthquake of 1995, it took approximately two days to restore 90% of the power. In the Great East Japan Earthquake of 2011, restoring 90% of the power took six days. When a disaster occurs, electricity is expected to be unavailable for 48 h or more, depending on the scale of the disaster. In recent times, people have relied on cellular phones for information and communication; however, power outages make it difficult to use these devices. In particular, if people are in evacuation shelters and the restoration takes a long time, electricity generation at these shelters becomes important for improving the quality of life of the people inside. However, to produce electricity, generators must be operated. Many generators require fuel, such as gasoline or propane gas, which are difficult to use in evacuation shelters and places with scarce relief supplies.

In these locations, power generation using natural energy sources, such as wind, sunlight, and hydraulic power, is better. Solar photovoltaic generation can produce electricity throughout the day and small amounts of electricity can be used at night by charging batteries. Even cloudy days, with little solar radiation, can generate approximately 20% of the electricity it produces on sunny days and 10% on rainy days. However, it cannot generate electricity at night. To compensate for this disadvantage, wind power could be used in combination. Wind power generation can be used regardless of the time of the day or weather conditions. These power generation methods could provide electricity in various locations and be used in evacuation shelters, for smartphones, and for cooking emergency rations.

In addition, personal lights and radios can be effectively used by installing portable items such as hand-cranked generators. Furthermore, students learn the

[1] Peace Boat Disaster Relief, Japan eds. https://pbv.or.jp/download/wagaya/workbook_sample.pdf

basics of power generation by assembling a hand-cranked power generation kit using a dynamo. Students learn the mechanisms of the generator, rectifier circuit, and recharging circuit.

These kits are made for various power generation methods. The solar photovoltaic generation kit consists of a solar panel, an automatic tracking system, and a charging circuit. Meanwhile, the wind power generation kit consists of a generator, a propeller, and an inverter and is installed in a high place, using pipes, to increase power generation efficiency. In this class, the assembled kit was installed on a rooftop to generate electricity for a smartphone. By assembling the kit from scratch, the students experience the challenges of setting up equipment and generating electricity at an evacuation shelter.

D. Production of Cardboard Beds

There is often a shortage of furnishing materials in evacuation shelters. However, cardboard (corrugated board) is easily available, is low cost, has high portability, and has low weight. Thus, it may be utilized to build furnishings such as sleeping beds.

We offer a subprogram to produce a cardboard bed. Students make Cardboard beds on the premise that they will use the beds they made themselves during the evacuation shelter experience. The students consistently produce their beds:

1. Define the functions and design specifications of the cardboard bed
2. Fabricate a mockup, made of thick paper, of the bed to verify the structural consistency of the design
3. Fabricate the actual cardboard bed and present it

Figure 1 presents snapshots of the subprogram in fiscal year 2021.

The students learn ways of improving the quality of life by producing furnishings with limited resources. They also learn that, contrary to their preconceived ideas, a cardboard bed, with good structural integrity, can be made.

Figure 1. Snapshots of the production of cardboard beds: students (left) cutting a corrugated board paper, (center) fabricating his own cardboard bed, and (right) presenting on his cardboard bed.

E. Evacuation Shelter Management Game (HUG)

The Hinanjyo Unei Game[2] (HUG) is a card game developed by the Shizuoka Prefecture officials to simulate the operation of an evacuation shelter. HUG has been introduced by local governments throughout Japan as a training exercise to ensure the smooth operation of evacuation shelters during emergencies and disasters.

Especially in cold regions such as Hokkaido, the method of operating evacuation shelters are extremely different from those in warmer regions. In Hokkaido, a new system called "DoHUG[3]" was developed, incorporating the lessons learned during the Great East Japan Earthquake, to operate evacuation shelters even during cold periods.

In this game, multiple people work as a team to manage evacuation shelters through regular discussions. The time of day, weather, and temperature change as the game progresses and requires different people to visit the evacuation shelter, including those with chronic illnesses, pets, small children, the elderly, and injured individuals, making it urgent to respond accordingly. The game is played with a set of 250 cards and a floor plan of a virtual or real school as the evacuation shelter. The cards consist of evacuee cards, event cards, and information cards. The evacuee cards contain detailed information about evacuees, such as name, gender, age, location, and house conditions. These are placed on the floor plan as actual evacuees to construct the evacuation shelter. The event cards determine changes in the situation and evacuation shelter management as per the change. The information cards provide information about what should be done at that time and changes in the environment, such as weather and temperature changes. Once 250 cards are exhausted, the participants will have operated an evacuation shelter for several days and would be able to identify problems through discussions, which would serve as a reference for future operations.

HUG tests students' problem-solving skills and helps foster skills that would be useful in actual evacuation shelter management.

F. Evacuation Shelter Experience

Places to evacuate can be divided into evacuation sites and shelters. The definition of this location is determined by the Cabinet Office Japan[4] and is specifically designated by each municipality. Evacuation sites could be places to evacuate when a disaster makes it dangerous for the entire community to live there, or places to temporarily wait until the disaster is under control. These places are not stocked with food and water. Specifically, large parks and universities are designated as evacuation sites.

Evacuation centers/shelters are places where people, whose houses have collapsed or are at risk of being damaged, take shelter for a certain period. Public facilities such as elementary and junior high schools and community centers equipped with drinking water and toilets are designated as evacuation centers. Our school

[2] Shizuoka Prefectural Earthquake Disaster Prevention Center: http://www.pref.shizuoka.jp/bousai/e-quakes/study/hinanjyo-hug.html

[3] Crisis Countermeasures Division, Hokkaido Government http://kyouiku.bousai-hokkaido.jp/wordpress/do-hug/

[4] Disaster Management in Japan https://www.bousai.go.jp/index-e.html

is designated as the latter.

Dormitory and boarding house students in the neighborhood may evacuate and take on management and volunteer roles. Therefore, a one-day experience at the school's gymnasium provides an opportunity to think about the core operations of an evacuation shelter, health management, and the needs, safety, and security of everyone. This becomes an opportunity to think about evacuation center management through HUG.

Objective: To experience life in an evacuation center, assuming that electricity and water supply have been cut off.

Implementation date: September/25-26/2020

Stockpiled food: Alpha rice, Calorie Mate

Stockpiled water: For cooking

Electricity: A private generator

Students are asked to bring enough food, water, warm clothes, and emergency supplies to spend the night. For sleeping, they need to assemble cardboard beds. They also have to devise a way to partition their beds to prevent corona infection.

The program could not be implemented in FY2021 due to the corona outbreak; however, the following are students' impressions of the program in FY2020.

- I was able to think more realistically about disasters through games such as emergency rations and HUG.
- It was freezing at night and I realized how important it is to take measures against the cold.
- It was so cold that I was shivering all the time and I never wanted to evacuate again.

On the day of the event, the weather was cloudy, with a maximum temperature of 16.3°C and a minimum of 6.6°C. The night was cold. Students' impressions suggest that the chill in the gymnasium was more than their expectations. This indicates that cold weather countermeasures are necessary for the Kushiro area. The students were also able to experience the difficulties of operating an evacuation center through HUG.

G. Disaster Prevention Goods Production

While it is essential to prepare for disasters by stocking emergency supplies in advance, it is not always possible to stock everything. Moreover, living in an evacuation shelter often limits the functions and activities of the infrastructure necessary for survival, and these conditions may persist for a long time. Therefore, this program aims to create goods, by using readily available items, that will help people in evacuation shelters.

The purpose is to cultivate the ability to envision problems in evacuation shelters and develop teamwork. Students form a team of three, discuss the situations that may be expected in an evacuation shelter and the functions required, and plan and create goods that can be produced with materials that are available in a disaster-stricken area.

We assign two phases to this program. The first phase is devoted to planning the disaster prevention goods to be produced by each team and discussing the necessary items. It is a precondition that many people could easily create such a product, each team used the Internet to research and examination of the disaster prevention goods required in the event of a disaster. The faculty procure items based on the list submitted by each team. In the second phase, the students receive advice from the faculty and each team create their disaster prevention goods through a trial-and-error process.

We mentioned water purifiers and simple toilets as examples of disaster prevention goods in the program description. This may be the reason that four of the five teams produced water purifiers and the remaining team produced a simple shower.

Of the water purifier teams, three produced filtered purifiers and one produced distilled purifier. We tested the water filtered by these prototypes through a water quality tester (WQC-22A, TDS meter) to determine whether it was suitable for consumption. Most of the water filtered through the water purifier had a larger Total Dissolved Solids (TDS*) value than the raw water (See Table 1). In addition, although there were no problems with the measured values, the number of bacteria could not be measured by the water quality tester. Therefore, if we want drinking water, we need to make more accurate purifiers or boil the water.

Table 1. The results of water purifier test.

Item Measured	Unit	Tap water	Raw water	Team 1	Team 2	Team 3	Team 4
Dissolved Oxygen	mg/l	0.28	0.26	0.25	0.25	0.25	0.25
Electric conductivity	mS/m	Lo	Lo	Lo	Lo	Lo	Lo
Concentration of NaCl	%	0.000	0.000	0.000	0.000	0.008	0.000
TDS	Ppm	93	81	109	72	106	139

*The TDS indicates the total concentration of inorganic salts dissolved in water (mainly calcium, magnesium, potassium, sodium, bicarbonate, chloride, and sulfate) and organic matter dissolved in water; the lower the number, the fewer impurities are present.

For the simple shower, the students used a heating agent (Morian Heat Pack, JP 3467729) in a container and attempted to convert cold water to warm water (40°C). In addition, we tested the water volume and pressure. In conclusion, the amount of heating agent was low and limited to raising 15°C water to 23°C. In addition, water was constantly leaking from the connection between the hose and the tank. The students were able to understand that the hurdles to creating disaster prevention goods were high in terms of processing and heat source.

Lesson and Evaluation Methods

In this section, we describe the student evaluation method. Of the seven items, thinking about power generation, playing an evacuation shelter management (HUG) game, and disaster prevention goods production are tackled in groups. The remaining items were dealt with individually.

The grade evaluation of this course is based on self-assessment and peer assessment.

Students evaluate the project achievement level twice – once on completion of the first 15 sessions, and again on completion of the second 15 sessions. The evaluation is on a 5-point scale (0 to 4) for 10 items related to self-

assessment and peer assessment. They are able to also provide comments. The ten items are as follows:

From the perspective of "having acquired independence and self-management skills"

1. You are good at time management
2. You can report, contact, and consult, as needed
3. You can set goals and look back on achievements

From the perspective of "working as a team while respecting others"

4. You can listen to others' ideas
5. Be able to express yourself while accepting others
6. You can contribute to collaborative work

From the perspective of "promoting discoveries and making new proposals"

7. You can collect and make sense of information
8. You can come up with ideas
9. You can develop logical considerations based on facts

For the 10th item, they are asked to mark the degree of achievement for "setting a goal for deliverables."

Analysis Using Reflection Sheet Information

We evaluate students' "commitment to group work" and "awareness of disaster prevention."

For group projects, we evaluate the values of self-assessment and peer-assessment indices: (1) Students have acquired independence and self-management skills, (2) Students can work as a team while respecting others, and (3) Students can promote discovery. For self-assessment, students evaluate themselves. For peer assessment, each student in a group evaluates the other three students.

The analysis is performed using numerical and text data. The difference between the current state and the 5-point scale is defined as the achievement level and the average value of the achievement level is calculated. The achievement level indicates the amount of improvement made. Text data analysis is performed by vectorizing the Wikipedia corpus and performing sentiment analysis to determine whether the content of the text is positive or negative, using the bert-based-japanese-sentiment model[5], which uses a pre-trained model. In addition, we analyze the characteristic nouns of the sentences.

A similar analysis of the evaluation of disaster preparedness awareness is conducted using the text data extracted from the reflection sheets and the final presentation materials. The categories of data used from the reflection sheets and deliverables are listed in Figure 2. The evaluation sheets were for 15 participants, identified from A-O.

Results and Discussion

The results of the self-assessment are shown in Table 1. The achievement level indicates that 11 students have improved the skills required for group work. The current state and end-of-course results for J, K, and L (achievement level = 0) are at the highest score of 4. This indicates that they could maintain their score without descending from the highest point. The average of the 5-point scale was 3.72.

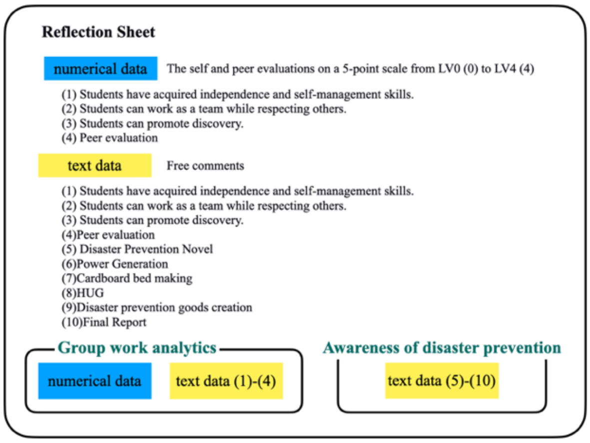

Figure 2. The numerical data and the text data in the reflection sheet and the final report.

The results of the achievement level in peer evaluation are shown in Table 3. Six students showed improvement, as viewed by others in the same group. The average of the 5-point scale was 3.91, suggesting that when evaluating others, they tend to rate them highly; thus, six of the nine students, with an achievement level of zero, had the highest score of 4. This suggests that all the skills were recognized by others during group work.

Table 2. The results of the achievement level for self-evaluation of each student (AL-s).

Students	A	B	C	D	E	F	G	H
AL-s	0.0	0.61	0.61	0.55	0.33	1.2	0.0	0.72
Student	I	J	K	L	M	N	O	Ave.
AL-s	1.0	0.0	0.0	0.0	0.55	0.65	0.44	0.44

Table 3. T The results of the achievement level for peer-evaluation of each student (AL-p).

Students	A	B	C	D	E	F	G	H
AL-p	0.0	0.0	0.0	0.0	0.0	0.0	005	0.05
Student	I	J	K	L	M	N	O	Ave.
AL-p	-0.05	0.0	0.0	0.0	0.01	0.16	0.05	0.018

Table 4. Results of sentiment analysis of text data on group work skills and disaster prevention awareness.

	Positive (%)	Negative (%)
Group work skill		
Independence and self-management skills	89.66	10.34
Work as a team while respecting others	89.66	10.34
Students can promote discovery	85.19	14.81
Peer evaluation	95.38	4.62
Average	**89.97**	**10.03**
Disaster prevention awareness		
Disaster prevention Novel	73.33	26.67
Power generation	78.95	21.05
Cardboard bed making	87.50	12.50
Disaster prevention goods creation	80.00	20.00
HUG	57.89	42.11
Final report	100.00	0.0
Average	**79.10**	**20.39**

[5] Tohoku University https://huggingface.co/cl-tohoku/bert-base-japanese-whole-word-masking

The sentiment analysis of the statements (See Table 4) revealed that 57.9%-100% of the statements were positive for all the items, with HUG getting the lowest value of 57.89%. The average of positive statements (89.97%) suggests that the participants contributed to the group.

However, there was some negative feedback, the primary being:

- It was challenging to deal with unexpected difficulties.
- I didn't have much input.
- Sometimes I didn't listen to what was being said.

The average of positive statements regarding disaster preparedness was 79.61% and, excluding HUG, the average was 83.96%, suggesting a promising approach to the class. The negative statements regarding HUG were:

- Experiencing the management of an evacuation center was difficult because of the many problems that came up.
- It was challenging to handle the overflow of people.
- The characters were so unique that everyone was perplexed.

The statements were negative because of the problems faced; however, the students either coped with the problems or understood the difficulty of the situation. Therefore, it can be deduced that these problems deepened students' awareness of disaster prevention.

We used the python library WordCloud[6] for natural language processing of sentences to intuitively grasp the keywords (nouns) that the students used in response to group work and disaster prevention awareness (see Figure 3). The font size represents word significance due to usage frequency. The bigger the font, the higher the significance.

(a) (b)

Figure 3. (a) Frequent noun words extracted from group work skill's text data. (b) Frequent noun words extracted from disaster prevention awareness's text data.

In group work, words such as "work (作業)," "idea (アイディア)," and "active (積極的)" were related to the sense of participation. In disaster prevention awareness, words such as "at the time of disaster (災害時)," "create (作成)," and "action (行動)" were related to efforts.

These results indicate that disaster awareness was enhanced through group work. Regarding improvement, the feedback was that "HUG would be easier to work on if implemented at the beginning because it will be helpful for disaster prevention novel and evacuation center management."

Conclusions

A project to raise awareness of disaster prevention was conducted in an interdisciplinary course. We conducted a quantitative and qualitative analysis of the teamwork and disaster awareness, using the data from the reflection sheets and report materials prepared by the students. The results showed that the students' achievements improved and the sentiment analysis of the texts confirmed that the students were optimistic about the project. Next year, we plan to change the order of the item implementation and structure a scaffold approach for the problems faced.

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The authors would like to thank former prof. T.Kusakari, former prof. T.Sakaguchi, and prof. T.Takahashi for launching this program together from the first year.

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[6] The python package index https://pypi.org/project/wordcloud/

ENHANCING KOSEN EDUCATION IN SPACE ENGINEERING THROUGH THE DEVELOPMENT OF KOSEN-1 AND KOSEN-2 CUBESATS

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Abstract

A low-cost space mission through a CubeSat has gained the attention of academic education in space engineering around the world. A CubeSat is as small as a palm-sized satellite, where the basic one unit (1-Unit) in size is defined as 10 cm x 10 cm x 10 cm. In 2011, we established a faculty-affiliated group called "KOSEN Space Collaboration Group" among several colleges of National Institute of Technology (abbreviated as KOSEN in Japanese). In the scope of all student participants in 51 colleges of KOSEN, we have been offering a various kinds of space education programs, including (1) KOSEN space academia, (2) KOSEN CubeSat development and operation and (3) all KOSEN space contest. (1) KOSEN space academia covers the online course on the basic process of satellite development and operation by means of CanSat kits and model CubeSat kits. The typical participants are about 80-100 students taking this course every year. (2) Second, we have developed two 2-Unit-size CubeSats since 2018. The first CubeSat named as KOSEN-1 was developed by the students and professors in 10 colleges of KOSEN in Japan. Since its launch on 9 November 2021, KOSEN-1 has maintained its polar orbit around Earth, communicating the telemetry data with seven college-based ground-tracking stations in Japan. The second CubeSat is called KOSEN-2, being planned to be launched by a JAXA Epsilon rocket in FY2022. The participants of this program can work on various roles for the CubeSat development and operation in the advanced level. (3) Last, all KOSEN space contest provides an opportunity that participants could propose a new mission idea for the next-generation KOSEN CubeSats and/or a specific scientific/engineering function using the KOSEN-X simulator, the same bus system as KOSEN-1 and KOSEN-2 CubeSats. The first contest was made remotely on 10 January 2022, where 10 teams among nine colleges presented their proposals and competed each other. We present the recent efforts on this KOSEN education through the development of KOSEN-1 and KOSEN-2 CubeSats.

Keywords: *engineering education, CubeSat, space engineering, space science, space contest*

Introduction

The technological advances of recent years provide a rapid growth of low-cost artificial satellite developments for the purpose of technical demonstration and academic education in colleges/universities, research institutes, and industries. One of these small satellites is called CubeSat, and one unit (1-U) used for its dimension is defined as 10 cm by 10 cm by 10 cm. CubeSats are mostly based on the commercial off-the-shelf components used for their mechanical and electrical functions. Another factor for the popularity is a short interval of the initial construction through the launch within a couple of years. This interval gives a rise of beneficial feedback for the evaluation of the subcomponent heritage and further challenges of the next CubeSat mission.

The accessibility to send CubeSats into space has been recently improved via the release from the International Space Station (ISS) or satellite launching vehicles. In the first way, a CubeSat is carried by an ISS-bound rocket (e.g., JAXA's H-II Transfer Vehicle) as a package wrapped with soft foam, and is then injected by

Japanese Experiment Module Small Satellite Orbital Deployer (J-SSOD) (JAMSS, 2015). The second way is to release a CubeSat from a satellite launching vehicle, which allows it to put in a various orbit insertion for the need of the satellite mission. This way is traditional since the dawn of space exploration but the current trend is to launch a constellation of satellites at once. For example, JAXA's Innovative Satellite Technology Demonstration program provides a multi-satellite launch by the Epsilon rocket, including a few CubeSats.

In 2011, a faculty-affiliated group called "KOSEN Space Collaboration Group" was established among several colleges of National Institute of Technology (abbreviated as KOSEN in Japanese). The activities from KOSEN Space Collaboration Group include various kinds of human resource education in space engineering for KOSEN students (Kitamura et al., 2022; Wakabayashi et al., 2019). In collaboration with the Ministry of Education, Culture, Sports, Science, and Technology (MEXT) after 2014, we have offered three kinds of space education programs: KOSEN Space Academia, All KOSEN Space Contest, and KOSEN CubeSat Development. KOSEN Space Academia offers an online course to learn the fundamental skill of developing and operating a satellite by means of CanSat kits and model CubeSat kits. The typical participants are about 80-100 students taking this course every year (Nakaya et al., 2020; Takada et al., 2019; Tokumitsu et al., 2021b). After the pre-contest was made in 2020 (Wakabayashi et al., 2022), the first All KOSEN Space Contest was made on 10 January 2022. This online contest was attended by 10 teams among nine colleges of KOSEN, who presented their proposals and competed each other. KOSEN CubeSat Development provides an advanced course to learn how to build actual CubeSats in order to let it survive in space and conduct a designated mission. We have been developing the flagship satellite called KOSEN-1 since 2018 (Imai et al., 2022) and the second satellite called KOSEN-2 since 2020 (Tokumitsu et al., 2021c). These three kinds of the programs are mutually interacted, and summarized in Figure 1.

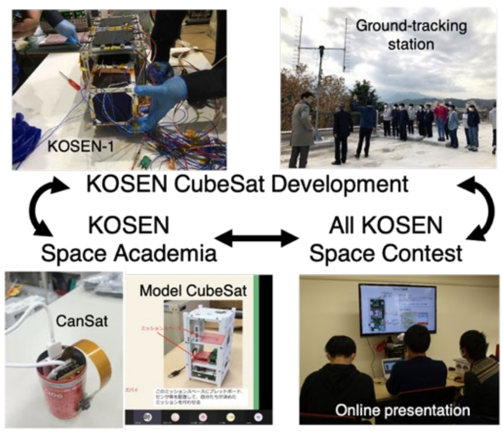

Figure 1. KOSEN space education programs: KOSEN Space Academia, All KOSEN Space Contest, and KOSEN CubeSat Development.

In this paper, we focus on the human resource cultivation in the advanced level for the development of KOSEN-1 CubeSat, which enhances KOSEN education in space engineering.

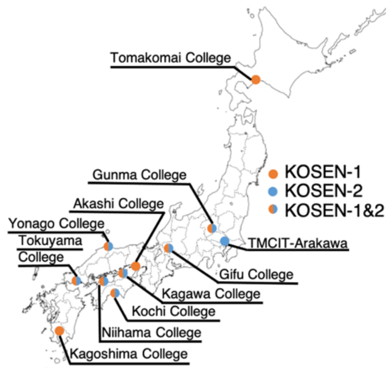

Figure 2. Locations of the institutes involving KOSEN CubeSat Development team

KOSEN CubeSat Development

KOSEN consists of 51 colleges (55 campuses in total) in Japan, in addition to three colleges in private and public, respectively. As shown in Figure 2, the current members of KOSEN CubeSat Development team are based in 11 colleges: 10 colleges for the KOSEN-1 project and 8 colleges for the KOSEN-2 project with overlapped 7 colleges. Figure 3 shows the computer graphics of KOSEN-1 and KOSEN-2 orbiting around Earth.

Figure 3. Computer graphics of KOSEN-1 and KOSEN-2 CubeSats orbiting around Earth.

On 12 December 2018, JAXA announced that KOSEN-1 2-U CubeSat was selected as one of the themes for the Innovative Satellite Technology Demonstration-2. This CubeSat is officially called Jupiter radio observation technology demonstration satellite. The CubeSat includes three key technologies to (1) demonstrate a high-accuracy attitude control system via the dual reaction wheel (DRW), (2) utilize an on-board computer with a Linux microcomputer board (Raspberry Pi Compute Module 1 (CM1)), and (3)

deploy a 6.6-m long dipole antenna from the CubeSat for Jupiter radio observations. The scientific target is to capture Jovian millisecond short-bursts in collaboration with ground-based radio telescopes to better understand Jupiter's decametric radio beaming structure (Imai et al., 2019). On 9 November 2021, KOSEN-1 was successfully launched by a JAXA Epsilon-5 Launch Vehicle and released in a low-earth orbit. On the same day, the continuous wave (CW) (i.e., Morse code radio signal) was captured, and five days later, the frequency modulation (FM) packet communications between the CubeSat and ground-tracking stations were confirmed. Currently, KOSEN-1 has been operated with seven college-based ground-tracking stations in Japan.

Following the hierarchy of the KOSEN-1, KOSEN-2 2-U CubeSat was selected as one of the themes for JAXA's Innovative Satellite Technology Demonstration-3 on 29 May 2020. KOSEN-2 has set two goals: the demonstration of collecting oceanographic data by means of a directional antenna with high-precious attitude control from DRW, and the demonstration of network-type satellite development schemes as a part of the human resource education in space engineering. Because the development of KOSEN-2 is currently in progress, this paper focuses on the development of KOSEN-1.

Table 1. 11 sub-system parts from the corresponding institutes and their roles.

Sub-System	Participated Institute	Role
OBC system	Kochi*	Meet the requirement of CubeSat operations
Power system	Kochi*, AUT	Provide sufficient powers to each component
Orbital analysis system	Gifu*	Estimate the orbital parameters and the prediction of falling satellite time
Thermal control system	Gifu*	Examine and simulate a thermal control system for KOSEN-1
Onboard camera system	Gifu*	Perform two on-board cameras functions properly
Structure system	Gunma*	Build a structure of KOSEN-1
Attitude system	Gunma*, Akashi	Incorporate DRW and Magnetorquer system
Antenna expansion system	Gunma*	Build and deploy a telemetry antenna and Jupiter radio dipole antenna
Communication system	Kagawa*, Yonago	Ensure the uplink and downlink of the satellite communications
Ground-tracking system	Yonago*, Kagawa, Kochi, Niihama, Gunma, Kagoshima, Gifu, Tokuyama, Akashi, Tomakomai, AUT	Build a ground-tracking station network and operate KOSEN-1 CubeSat from the ground
Jupiter radio observation system	Niihama*, Kochi	Perform a software-defined radio (SDR) receiver to capture Jupiter's radio signals

* Lead institute, AUT = Aichi University of Technology

Development of KOSEN-1 CubeSat

KOSEN-1 is the first CubeSat mission proposed by the KOSEN Space Collaboration group. The participated students take part in this project via either the club activity or the graduation project. For example, Gifu College has Space Engineering Research Association, and a couple of members are in charge of the development of an onboard camera system for KOSEN-1. In addition, when KOSEN students are fifth grade (or sometimes they start at fourth grade), they have an opportunity to conduct research through a graduation project under the direction of the department's faculties. The topic of the research depends upon the specialty of their faculties. Such involvement into this project includes from most of the participated colleges. A total of 11 sub-system parts among the KOSEN-1 development are classified according to Table 1. Figure 4 shows the overview of KOSEN-1. As shown in Figures 4a and 4b, the internal structure of KOSEN-1 contains 1/3 of the electronic board, 1/3 of DRW and 1/3 of Jupiter radio dipole antenna. Figure 4c shows the outlook of KOSEN-1 Flight Model 1.

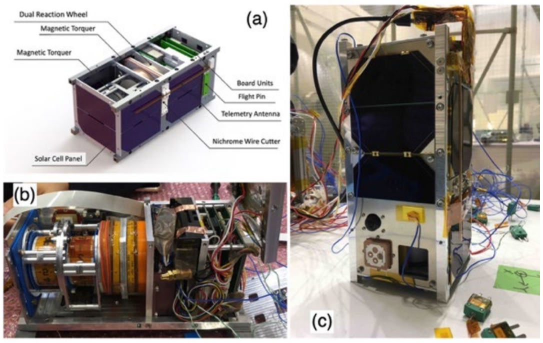

Figure 4. Overview of KOSEN-1. (a) Locations of the main parts distributed with labels, (b) Internal structure of KOSEN-1 Engineering Model 2, and (c) Outlook of KOSEN-1 Flight Model 1.

As the development team institutes are distributed over Japan (Figure 2), taking advantage of the telecon software Skype for Business and Microsoft Teams, we held a weekly online team meeting from 11 December 2018 through 28 September 2021 for a total of 98 times. The average participants per a meeting are 18 people (including 12 students). In this meeting, each sub-system leader (mostly a lead KOSEN student) reported on the current status of the development to the team and exchanged the ideas for the further improvement of the system. In parallel, we utilized a cloud-based chat tool Chatwork in order to rapidly share on-going information and exchange further ideas. Also, all materials including the presentations and the experimental data are stored in Google Drive. The access to these software tools is restricted with the team members only.

Roughly speaking, the development of CubeSat can be divided into three models: Bread-Board Model (BBM),

Engineering Model (EM), and Flight Model (FM). Also, each model is examined in order to prepare for the verification of the system during the launch and orbing in space. This kind of the environmental evaluation tests are further classified as Thermal Vacuum Test (TVT), Vibration Test (VT), and Impact Test (IT). Table 2 shows the summary of the KOSEN-1 development regarding the environmental evaluation tests, and some of the tests are photographed in Figure 5.

Table 2. Environmental evaluation tests for KOSEN-1 CubeSat in Center for Nanosatellite Testing, Kyushu Institute of Technology, Japan.

Event	Date	Participated team members (students)
BBM TVT	5-7 March 2019	4 (2)
EM1 TVT	3-5 March 2020	3 (1)
EM1 VT	9-10 March 2020	2*
EM2 TVT	29-30 September 2020	3 (1)
EM2 VT	1-2 October 2020	7 (5)
EM2 IT	2 October 2020	6 (5)
FM1 TVT	22-24 March 2021	6 (3)
FM1 VT	25 March 2021	5 (3)
FM1 IT	26 March 2021	5 (3)
FM2 TVT	29-30 June 2021	4 (1)
FM2 VT	8 July 2021	2 (1)
FM2 IT	9 July 2021	2 (1)
BBM = Bread-Board Model, EM = Engineering Model, FM = Flight Model, TVT = Thermal Vacuum Test, VT = Vibration Test, IT = Impact Test * Due to the COVID-19 pandemic, the travel to the site for students were cancelled; they joined this test, remotely.		

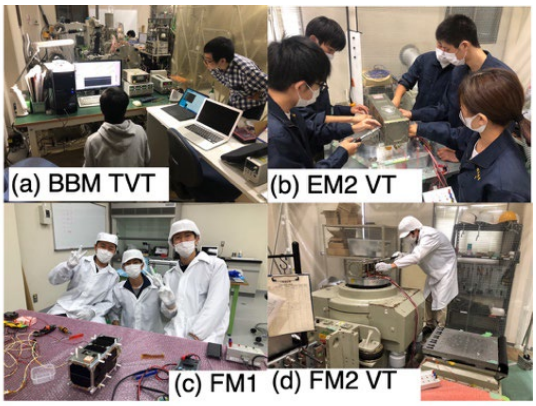

Figure 5. Photos during KOSEN-1 environmental evaluation tests. The labels correspond to the events listed in Table 2.

One of the new technology demonstrations for the KOSEN-1 development is to use OBC (CM1) installed on Raspberry Pi OS and design a customized electric board called CubePi-Board. This Debian-based Linux OS along with a general-purpose input/output (GPIO) gives a flexibility to control electronic devices via Python programs or Bash scripts or both, providing their program portability. Additionally, the economic advantage using the commercial off-the-shell components yield a stand-alone software development from each institute. The price of CM1 and equivalent component Raspberry Pi Zero are $30 and $5-10, respectively. Also, Raspberry Pi Zero is widely distributed as a main OBC as a part of KOSEN Space Academia. Hence, both portability and economic advantage were boosting our development for the CubeSat even from the remote individual location of the participated institutes. After the individual software development was made via GitLab, we verified these programs in KOSEN-1 FM2 through the end-to-end test (i.e., a communication loop test between the CubeSat and ground-tracking transmitter in a room of Kochi College). The main support from this part came from a few KOSEN students from Kochi College. Because the serial interface of KOSEN-1 is accessible from the outside computer console (e.g., TeraTerm and Terminal), we could update the designated software folder to OBC directly. This way is a straight-forward to mitigate all programs to the CubeSat. We built control commands that are a mixture of Python and Bash scripts in activating specific sensors and operations inside of CubeSat. In the end, we delivered 212 control commands onboard KOSEN-1. The summary can be found in Table 3.

Table 3. Control commands installed in KOSEN-1.

Sub-System	Control Commands	Lead Institute
OS system	29	Kagawa
OBC system	12	Kochi
Power system	26	Kochi
Jupiter antenna system	3	Gunma
Jupiter radio observation system	41	Niihama
Camera system	28	Gifu
Communication system	31	Kagawa, Yonago
DRW system	16	Gunma
Magnetotorquer system	21	Gunma
CW system	10	Yonago

Not only does our educational system build a CubeSat but also operate it from seven ground-tracking stations in Japan. This ground-tracking network is comprised of Yonago College, Kochi College (2 stations), Kagawa College, Niihama College, Gunma College, and AUT. Because the amateur satellite is required to have the transmitter power at the maximum power of 50 Watt, each institute has 1-3 students and some faculties having Amateur Third-Class Radio Operator. After establishing the FM packet communications between KOSEN-1 and the ground-tracking stations in the amateur frequency band, we attempted to perform several control commands. They include the monitor of CPU usage, the 9-axis measurement of the CubeSat, the performance of DRW, the photographs from two onboard cameras, and the in-orbit test of Jupiter radio SDR receiver. In addition, CW provides 6 kinds of data: (1) received signal strength indicator, (2) battery temperature, (3) battery voltage, (4) battery current, (5) load current, and (6-9) solar panel -Z, -Y, -X power supply in two hexadecimal digits. These numbers are translated into the physical parameters via the calibrated tables done on the ground.

These house-keeping data are valuable to monitor the healthy check of KOSEN-1. Hence, students can learn how to operate CubeSat via the FM packet communications and collect the house-keeping data by decoding the CW Morse signals with the letter being essential for the basic telecommunication.

Discussions

The interval of KOSEN-1 development is about two and half years before we handed it to JAXA for the launch. Due to the COVID-19 pandemic, the school classes were closed and switched to online, and even domestic travels were restricted for most of the participated institutes especially in the early-mid 2020. In this interval, EM1 VT was scheduled at the site for a few students from Gunma College, but they ended up joining this test, remotely. While we are well-trained under the network-type scheme, we continued to work together remotely in developing sub-system components and software programs.

One of the difficulties is to rig a CubeSat, physically. Because the conventional development of a CubeSat is more likely to be achieved in one major institute, the corresponding students can easily grasp an image when encountering a problem of fitting and examining space versus the requested objects. In our case, the original KOSEN-1 model was either located in Gunma College or Kochi College. Therefore, students from the other institutes faced some difficulties thinking about this problem. Our approach is to solve this problem by developing 3D CAD images for KOSEN-1 (Figure 6), so that all development team members can examine the internal and external structure of KOSEN-1.

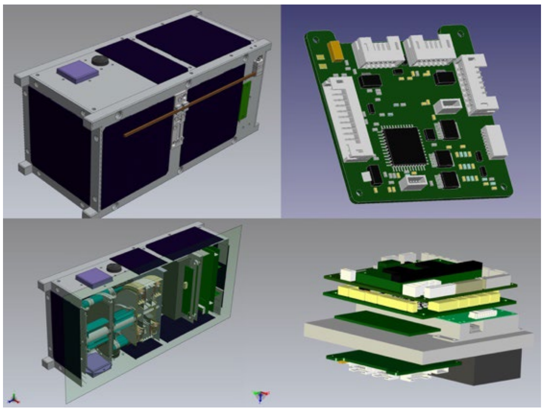

Figure 6. 3D CAD images for KOSEN-1 Flight Model 2.

Summary

This paper reports our recent efforts on enhancing KOSEN education in space engineering through KOSEN CubeSat development. Specifically, we exemplify the development of KOSEN-1 from the selection of its CubeSat by JAXA through the ground-tracking communication via the environmental evaluation tests. Most of the parts were newly developed from scratch. This network-type satellite development scheme introduced during KOSEN-1 development is a benchmark to the on-going development of KOSEN-2 CubeSat. We hope to propose a series of KOSEN CubeSat project for the sustainable KOSEN education in space engineering, so that our preliminary attempt would be a good example adopted in a rapid KOSEN student cycle of 5 years (or 7 years including the advanced course of KOSEN).

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We are pleased to acknowledge JAXA for their support in developing KOSEN-1 and KOSEN-2 CubeSats and sending KOSEN-1 to space. This work was supported by the Ministry of Education, Culture, Sports, Science and Technology of Japan (MEXT) through the FY 2021 Aerospace Science and Technology Promotion Fund, Aerospace Human Resource Development Program, “Next Generation KOSEN Space Human Resource Development through Continuous Nano-Satellite Development and Operation” (Principal Investigator: National Institute of Technology, Niihama College).

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SCENARIO-BASED DIGITAL ESCAPE ROOM AND SIMULATIONS TO ENHANCE LABORATORY SKILLS AND ENGAGEMENT

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Abstract

A scenario-based digital escape room and laboratory simulations were designed to provide opportunities for students to explore real-world situations in a safe and controlled environment. It helps students integrate their technical laboratory knowledge against practical industry applications. Aside from conducting experiments, students evaluate test results to bridge the gap between data acquisition, analysis, and decision-making. Students were challenged to investigate a crime scene as a supplementary laboratory activity. It incorporates the chemistry laboratory course material where students need to conduct an acid-base neutralization experiment. It aims to engage the students and improve their cognitive and collaboration skills.

Eighty-seven students obtained an average of 0.046M HCl concentration vs. 0.05M HCl theoretical concentration of the unknown liquid sample at 8%Error. The traditional laboratory content delivery ends at this stage, where students show proficiency in testing laboratory samples. A post-session survey was circulated to assess student learning and engagement. It consists of a 5-point Likert question to gauge whether students learned and enjoyed at the same time. A mode score of 4 was obtained, equivalent to a satisfactory interval range. It showed that 86.2% of students were satisfied, 8.0% neutral, and 5.8% dissatisfied out of n=87 students. Satisfied students found the lab activity "fun and at the same time, educational." Neutral and dissatisfied students highlighted that the time given was insufficient. A free-response question asking for the identity of the murderer was also included. The students suspected 5 out of 7 characters, and 52% pinned down the actual murderer. The variations in the suspected murderer were expected as breadcrumbs of information were provided to gauge students' decision-making, inductive reasoning, and ability to interpret complex situations. Results showed that the digital escape room and laboratory simulations positively impacted the student's cognitive skills, collaboration, and engagement in the chemistry laboratory. This approach was recommended to other similar subjects as different scenarios can be adapted, designed, simulated, and tailored to fit different real-world contexts.

Keywords: *scenario-based learning, digital escape room, laboratory simulations, active learning, teaching and learning, student engagement*

Introduction

A scenario-based learning (SBL) environment is an instructional environment where students are exposed to carefully constructed, realistic and authentic situations, problems, or contexts where they can apply relevant knowledge and practice skills. According to Muhamad et al. (2012), scenario-based learning is a promising tool to help students acquire science knowledge when integrated into a teaching and learning enhancement system.

An escape room is an ideal scenario where participants must work together to achieve a common goal. In recent years, digital escape room has become an increasingly popular educational activity because it involves the challenge of solving a complex problem and is a way to foster collaborative skills. It also helps to motivate and engage students through active learning.

Scenario-based learning and escape room are aligned with the Situated Learning Theory, which states that learning should be authentic and take place in the environment in which it would normally be applied. It was first presented by Jean Lave and Etienne Wenger in 1991, explaining that learning is supposed to be unintentional. The authors call the unintentional nature of learning the legitimate peripheral practice, where learners become an expert as they engage and participate actively in the sociocultural practices of the community.

The existing chemistry laboratory course materials were supplemented with a crime scene digital escape room scenario. It was designed to promote an active learning strategy and address specific learning outcomes for Temasek Polytechnic Year-2 Biomedical Engineering (BME) Students. It follows John Keller's ARCS model of motivational design. According to Keller (1983), an instructional designer can routinely improve a learner's motivation to learn by focusing on attention, relevance, confidence, and satisfaction (ARCS). In 2016, he defined motivational design as a "process of arranging resources and procedures to bring about the changes in

motivation." This subject delivery enhancement and supplementation intend to develop BME students' understanding of the interrelationship between chemistry concepts, technical laboratory procedures, and their practical industry application. Its key objective is to bridge the gap between data acquisition, analysis, and evaluation after completing a laboratory experiment. Additionally, it aims to enhance cognitive skills in critical thinking, problem-solving, and communication. It also aims to engage the students through active learning and collaboration.

Methodology

SBL checklist suitability assessment: The idea of creating an escape room scenario for year-2 BME students for their chemistry subject was assessed for its suitability using the scenario-based learning checklist published by Clark in 2009. For checklist 1, the learning outcome was expected to be based on analytical skills and problem-solving skills development, where students were required to analyze the concentration of an unknown liquid sample through acid-base neutralization. In checklist 2, crime scene investigation involves the handling of human biological samples, which requires approval from the Institutional Review Board (IRB). Since risk was involved, it would be difficult for students to execute the activity physically. For checklist 3, year-2 BME students already completed a Human Anatomy and Physiology subject in the April semester. The relevant chemistry topic of acids and bases had also been covered in the lessons and tutorials. The students were already equipped with the prior knowledge needed to aid their decision-making in evaluating the clues and puzzles. Checklist 4 asked whether time and resources were available to design, develop and test the SBL approach. A digital escape room was used to provide context because the development of a physical escape room was not feasible. There are drawbacks to developing a physical escape room that includes a need for infrastructure upgrade, demand for resource planning and budgeting, and limitations of the number of students that can do the escape room at a time. It was also time-consuming and required maintenance. Checklist 5 asked whether the content and skills remain relevant for long enough to justify the development of SBL. Since the escape room scenario was a digital content, it solves the issue of its longevity and relevance. It can be easily updated and revised to adapt to any technological change.

Learning outcomes: Biggs' Constructive alignment (2003) was performed after the feasibility of the escape room was established. The intended learning outcomes were patterned according to Bloom's revised taxonomy (2001). It was considered to help improve the student's critical thinking, problem-solving, communication, and collaboration skills. The existing learning outcome falls under the analyze category in the revised taxonomy. Two intended learning outcomes were added on top of the existing learning outcome. Students were required to collaboratively evaluate evidences of an ill-structured problem and to formulate an evidence-based conclusion. The additional learning outcomes are two hierarchies higher in Bloom's framework: evaluate and create. Instead of just doing the acid-base neutralization experiment to achieve analytical testing proficiency, a data analysis, evaluation and conclusion were required (Figure 1).

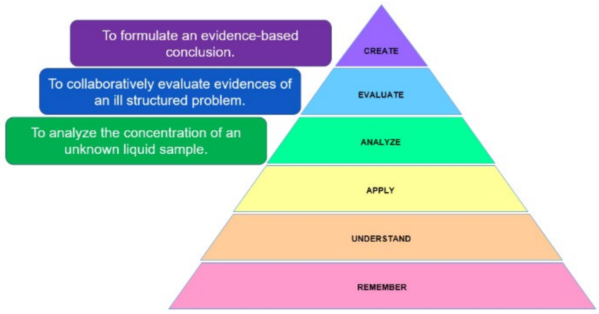

Figure 1 Case 56G1 escape room scenario learning outcome

Digital escape room design and development: The digital escape room scenario was designed to supplement the existing chemistry laboratory course materials. It was created and presented using google slides, a free online slideshow maker. The scenario simulates a crime scene (Figure 2), where the students were required to role-play as a forensics student intern. It includes nine clues or puzzles presented as pieces of evidence that students can investigate in a linear or non-linear manner.

Figure 2 Crime Scene Digital Escape Room Scenario

The students can then interact with each piece of evidence. As they move, breadcrumbs of information about crime scene case 56G1 reveal. Evidence 1 showed fictitious information about the victim Beatrice D. Gabriel, a lady in her thirties who was found dead. Her case file summarizes her personal data and bank details. There was a dried blood stain found in a torn lady's dress in evidence 2. A lump of paper bills and coins was the third piece of evidence. It includes information on three bank withdrawals and remittances from an overseas account. Evidence 3 and 7B summarize the interview logs pulled from two animated video footage (Figure 3). Evidence 4 was a dried human blood stain splashed on a wardrobe. Evidence 5 was a knife that contained traces of Isopropyl alcohol, cleaning bleach, Hydrogen peroxide, and Ammonia. Evidence 6 was assorted home-

baked cookies with no bite or saliva marks, but it contained traces of Thallium.

Figure 3 Interview log (Animated Video Footage)

Evidence 7A was an empty wine glass containing a colorless acidic liquid solution. This solution was given to the students and used as an acid-base neutralization sample. The identity of the solution was unknown to the students.

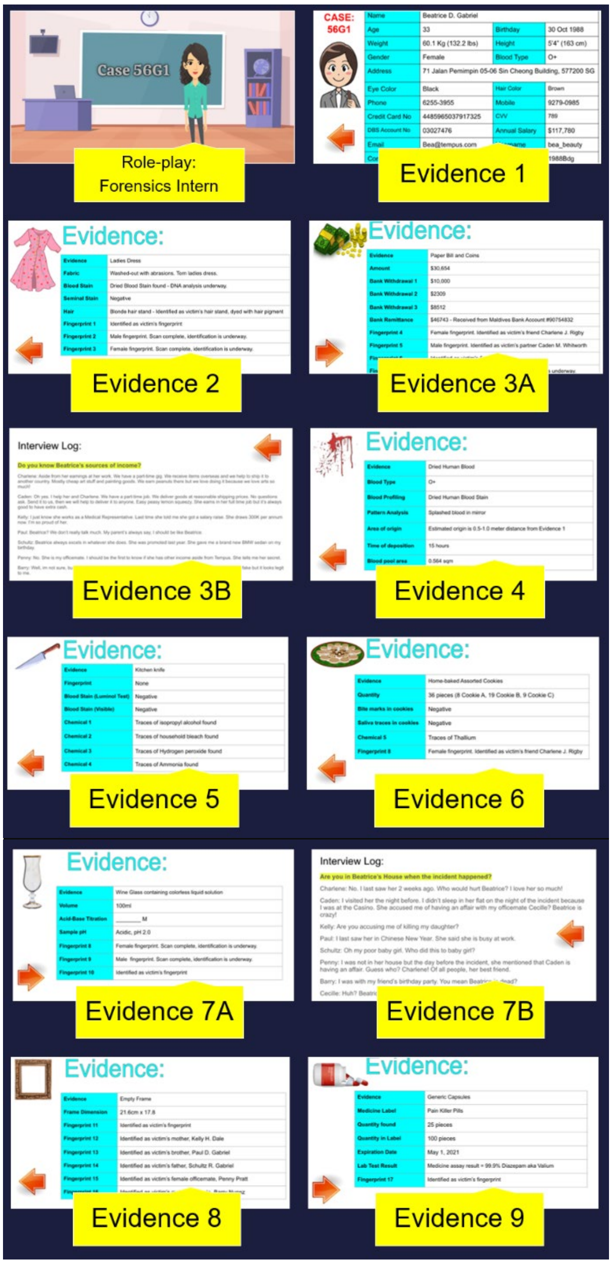

Figure 4 Case 56G1 Crime Scene Storyboard

Evidence 8 was an empty art frame, and Evidence 9 was a container of a generic capsule that was found to be 99.9% pure Valium. Some of the evidence includes additional information that states that the DNA and fingerprint analysis was underway. Figure 4 illustrates the crime scene storyboard and the output of the interactable evidence.

Subject content integration and delivery: Two lecturers were in-charge of delivering the ESC1003 Chemistry content to the year-2 BME cohort (n=125 students) in the SY2021/2022 October semester. The students in 5 laboratory classes were divided into groups at the beginning of the session, and the crime-scene digital escape room was introduced. Based on the instructions, the students were required to collaboratively solve crime scene case 56G1. The students need to check the pieces of evidence like fingerprints, missing objects, and murder weapons, to name a few. Each student was given a sample labeled as Evidence 7A, which they were required to use to conduct an acid-base titration experiment. The students have to conduct their experiment independently by following the Acid-Base titration protocol and reporting the concentration of the solution. The students in each group compared their results to their groupmates and agreed on which final concentration to report as a group. A post-session questionnaire and exit ticket survey were circulated to the students. It required the students to submit the concentration obtained from the titration analysis. It includes a free response question, "Based on your findings, who have a strong motive to kill Beatrice?" and a follow-up question, "Why do you think so?" To gauge student engagement, the students were given a 5-point Likert Scale which states, "Did you learned and enjoyed at the same time?" Next is a free response field where the students can write their feedback.

Debrief and reflection: A debrief was conducted to inform the students of the theoretical concentration and identity of evidence 7A. Students were asked to compare their actual results versus the theoretical value of 0.05M HCl. Then, students were asked to recount the laboratory activity and summarize their experience. They were also asked to reflect on its implications. From there, students were asked on how can they apply the lessons learned from the escape room scenario in the future and the practical and industrial relevance of the experiment.

Results and Discussion

Year-2 BME students collaboratively investigated crime scene case 56G1. All students independently performed the acid-base titration experiment in three replicates using Evidence 7A as an unknown sample. The pooled data obtained from 87 students resulted in an experimental mean concentration of 0.046M HCl and 0.004M HCl standard deviation (Figure 5). An 8% error was obtained from the average data when compared to the theoretical concentration equivalent to 0.05M HCl. The traditional subject delivery ends at this stage, where

students have established their proficiency in conducting laboratory experiments.

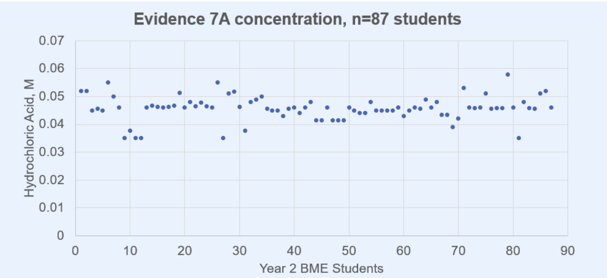

Figure 5 Reported concentration of evidence 7A sample

The outcome of the escape room scenario was also evaluated. In the post-survey question, "Based on your findings, who have a strong motive to kill Beatrice?" Forty-five students, equivalent to 52%, pinned down Charlene as the murderer (Figure 6).

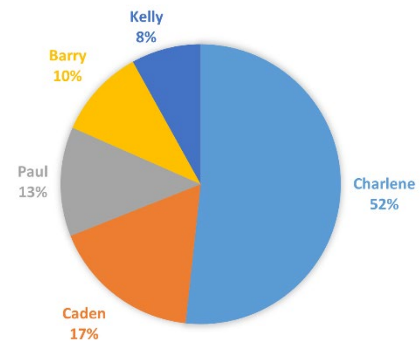

Figure 6 Crime scene suspects based on students' evaluation

Five out of seven characters were suspected by the students. The variations in the suspected murderer were expected as breadcrumbs of information were provided to gauge students' decision-making, inductive reasoning, and ability to interpret complex situations. The students communicated on their basis to glean evidence of the suspect's guilt or innocence. In the follow-up question, "Why do you think so?" the students formulated their rationale for identifying the suspect (Figure 7). The students inductively reasoned that the most likely motive for someone to kill Beatrice was jealousy. Other possible motives include financial gain, hate, or revenge.

Figure 7 Word cloud generated from the student's conclusion

The students were engaged and motivated to conduct the experiment and solve the crime scene during the class activity. A mode score of 4 was obtained in the 5-point Likert question on whether the students learned and enjoyed at the same time (Figure 8). This was equivalent to the satisfactory range. The majority of students (86.2%) were satisfied with their experience. There were 8.0% who were neutral and 5.6% who were dissatisfied.

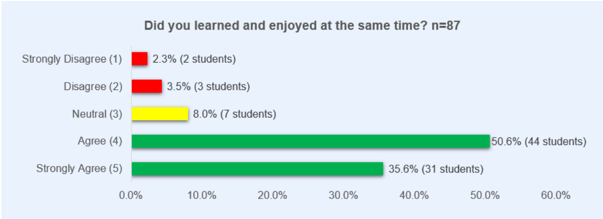

Figure 8 5-point Likert scale to gauge student engagement

Student feedback showed that satisfied students found the activity "fun and, at the same time, educational". Some students said that they were given a chance to solve a murder case and make them feel like a detective. They also mentioned that the escape room was an exciting way to learn. It was an enjoyable class as they learned the chemistry concepts of acids and bases and its laboratory applications. Neutral and dissatisfied students mentioned that they also enjoyed the session but needed more time to evaluate the pieces of evidence properly.

The students were informed that the identity and concentration of evidence 7A was 0.05M HCl. The students compared the theoretical value with the average concentration reported by the group and individually obtained. The students were asked to recount their laboratory experience and to note the possible sources of errors. Some students had difficulty identifying the stable light pink endpoint, while others over-titrated the solution. The students realized during the reflection stage that accurate and precise data was crucial in making sound decisions. If that were a real-life case, almost half of the class would blame the wrong suspect and potentially put that person in jail. Some students argue that since the evidence was incomplete, the new evidence could lead to another suspect, and they could be right. The lecturers mentioned that the scenario should be treated like a lab sample. The test and interpretation should be made objectively. The judgment of the analyst should not be clouded by bias or speculation. If new pieces of evidence and laboratory results come in, judgment should be made, but conclusions should always be based on facts at the point of analysis. The students also discussed how they could apply the lessons learned from the escape room scenario. They mentioned that working in the lab was a big responsibility, so they must ensure that protocols are followed and appropriately performed to generate reliable results. They also managed to relate the practical relevance and industrial applicability of what they had just learned in the laboratory.

Going back to the ARCS model of motivation, students' attention was obtained by using perceptual

arousal; the crime scene scenario enticed the student as it was patterned in a real-world example and included conflict. There was also a component of inquiry arousal as the crime scene scenario started with a role-play, where students acted as forensics student interns. There was variability in the content delivery as puzzles, pieces of evidence, animated videos, and discussions were used. The relevancy was established through goal orientation. The students could relate to why they were learning this and see its applicability and alignment to their future careers as Biomedical Engineers. As students succeeded in achieving the learning outcomes, confidence was established. Success opportunities were provided by giving feedback to the students on how they can improve their skills by knowing their sources of error. Each student was also given their own control over their learning and skills development. The students were motivated to learn and improve their skills because of the fun and challenging component of the crime scene scenario. Satisfaction was achieved through the use of intrinsic reinforcement. The fun and challenging component of the scenario motivated the students to learn the content and continue to improve their skills. The extrinsic reward received by the students from the lecturers was positive feedback, especially to those who successfully identified the murderer. Positive and constructive feedback was also given to the rest to encourage them to do well and improve their skills.

Results showed that supplementing the chemistry subject with an escape room scenario enhanced the subject delivery of the topic acids and bases. The class discussion showed that students managed to relate the relationship between these concepts and its practical application. Constructive alignment of the learning outcomes helped to bridge the gap between data acquisition, titration analysis, evaluation, and conclusion generation. The additional learning outcome helped the students improve their critical thinking, problem-solving, and communication skills while actively learning during the group work activity. The students were engaged in the class activity and motivated to perform well as they now understand the connection between the need to study the topic and its industry relevance (Figure 9).

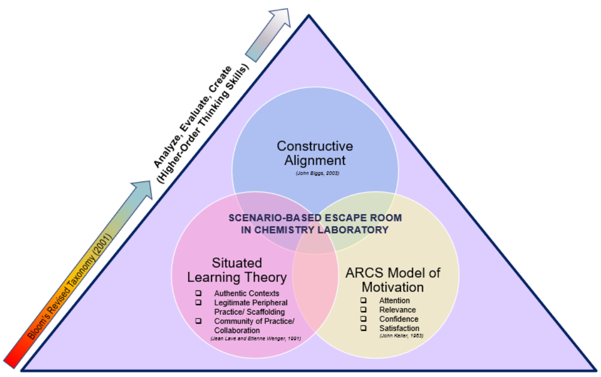

Figure 9 Subject enhancement and student engagement

The chemistry subject supplementation and scenario-based digital escape room integration approach can be applied to other similar subjects. Different settings and themes can be used to make the escape room scenarios. It can be tailored to fit real-world problems and situations and can be used to simulate other practical and industrial applications.

Conclusions

Integrating the scenario-based escape room in the existing laboratory course materials enhanced the delivery of the Chemistry subject taken by Temasek Polytechnic Year-2 Biomedical Engineering students. This approach positively impacted student engagement. Students could solve real-world problems while escaping the traditional lab, which helped them develop higher order thinking skills. This approach was recommended to other similar subjects as it can be easily adopted and tweaked according to the intended learning outcomes. The escape room scenarios can be designed using different settings and themes. It can simulate other practical and industrial applications and be tailored to fit various real-world problems and situations.

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EVIDENCE-BASED APPROACH TO CULTIVATING INTRINSIC MOTIVATION, GRIT AND GROWTH MINDSET VIA THE PERMA MODEL

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Abstract

This paper examines the implementation of PERMA model (abbreviation of Positive Emotions, Engagement, Relationships, Meaning and Accomplishment) for inculcating essential traits of self-directed learning (SDL). The initiative is especially important with the transformational move towards e-learning in tertiary education during pandemic times. Embracing positive education facilitates holistic development among learners through the promotion of good mental wellbeing and social responsibility. Learning is therefore enhanced by creating the positive emotions and experiences through a purposefully designed curriculum and its accompanying teaching practices that would bring forth the optimal academic and life outcomes in individuals. In our study, the PERMA model forms the overarching framework to deliver a customised learning programme, EIPA(M) – which stands for Eudaimonic Identity, Purpose, Autonomy and Mastery – for year one students from the Diploma in Perfumery & Cosmetic Science (DPCS). This proactive intervention provides a purposeful outcome by integrating Singapore Polytechnic's (SP) Pedagogy for the Professions (P4P) on Projects with CDIO Elements and industry practices with the setting of mastery-oriented goals and the deployment of personal Values In Action (VIA) character strengths championed by Christopher Peterson and Martin Seligman (2004). The interventions aim to nurture learner's intrinsic motivation, growth mindset and grit. Data are collected based on DPCS students' survey responses, on a 5-point Likert scale, for a series of questionnaires associated with the measured attributes. The data indicates promising outcomes to elicit the effectiveness of the intervention and the use of mastery-oriented goal as the instrument for the cultivation of intrinsic motivation, growth mindset and grit. Positive associations are also made among the PERMA elements and VIA character strengths with the SDL attributes. The infusion of PERMA-embedded activities for deliberate practice ought to be executed continually in the curriculum in order to reap the full potential of positive education since building a strong foundation for a positive mindset to augment self-directed learning is after all a cumulative life-long process.

Keywords: *intrinsic motivation, grit, growth mindset, PERMA, positive education, self-directed learning*

Introduction

Positive education is gaining traction in the education arena with the fundamental goal to promote a flourishing school community (e.g., Seligman et al., 2009; Norrish, 2015b). The Strath Haven Positive Psychology Curriculum and Geelong Grammar School Applied Framework for Positive Education are two exemplary initiatives which leverage on this proactive approach to drive optimal students' academic and life outcomes. In additional to a well-designed curriculum and best teaching practices, positive education helps to boost the personal wellbeing and positive social integration by reinforcing students' positive traits in personal strengths, values and compassion. With the implementation of a work-based training programme in the Diploma in Perfumery & Cosmetic Science course, known as Industry Now Curriculum (INC), it is imperative for students to learn to cope with its rigour which further warrants the need for a SDL culture.

The PERMA model in Fig. 1, provides both theoretical and practical insights on the application of positive psychology at different levels of optimal functioning (e.g., Seligman, 2011; Waters, 2011; Norrish, 2015a; Kern et al., 2015; White, 2018; Riedel et al., 2020).

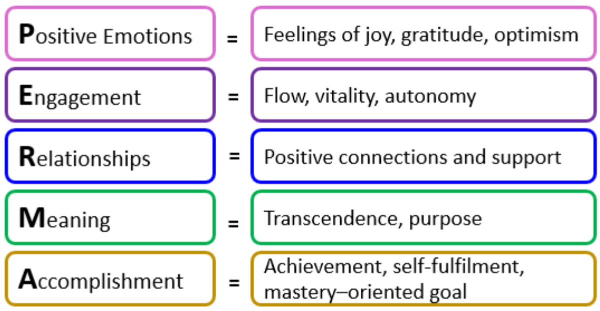

Fig. 1: Dr. Seligman's PERMA theory of well-being.

This multidimensional understanding of wellbeing is based on the five key pillars of Positive Emotions (i.e. joy, gratitude, optimism), Engagement (i.e. flow, vitality, autonomy), Relationships (i.e. positive human interactions), Meaning (i.e., transcendence, purposeful existence) and Accomplishment (i.e. achievement, mastery-oriented goal pursuit). The benefits of PERMA model inspires us to explore an authentic learning experience of the course that would harness the concept for cultivating desirable SDL attributes of intrinsic motivation, growth mindset and grit (e.g., Dweck et al., 2019, ; Duckworth, 2016; Ryan & Deci, 2000 & 2020) in DPCS students. On a broader perspective, this initiative fully aligns with our institutional vision of building a caring community of inspired learners committed to serve with mastery.

Materials and/or Methods and/or Pedagogy

Fifty-four DPCS students volunteered to undergo a learning journey as depicted in Fig.2. Deeper learning is enforced through the formation of small project groupings. Each group was mentored by two to three seniors. The freshmen, having limited course exposure, would benefit from the mentorship from their seniors who underwent similar prior training experiences. The EIPA strategy will form the basis of this intervention while domain-specific mastery outcome, (M), is excluded from this study since it requires a longer-term fulfilment and shall be further addressed in opportunities offered by the Industry Now Curriculum (INC) and enhanced internships subsequently in the later part of the curriculum.

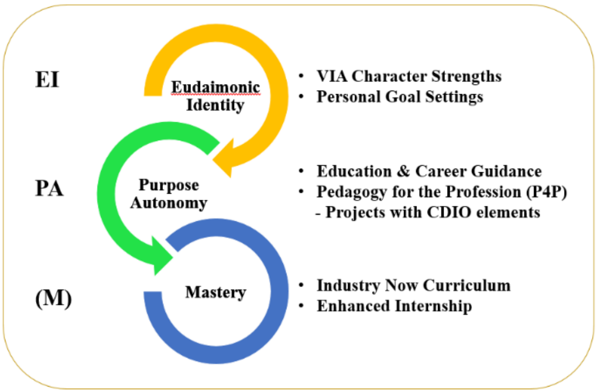

Fig. 2: The EIPA(M) learning strategy (EI stands for Eudaimonic Identity, PA stands for Purpose and Autonomy, and (M) stands for Mastery).

A series of workshops are designed to encapsulate the five pillars of the PERMA model for the purpose of inspiring positive personal growth and cultivating the desirable SDL attributes. Activities in the first workshop are designed for establishing a eudaimonic identity through in-depth self-reflection, setting of mastery-oriented goals and application of VIA character strengths in order to promote positive emotions. Thereafter, the students are exposed to greater insights of the course and industry. In workshops 2 and 3, students are taught on fragrance ingredients and formulation techniques, followed by workshop 4 of which a seminar conducted by a practitioner from the aromatherapy industry to understand how aromatherapy can help to promote health and wellness. The intention is to nurture hope and optimism that enables students to make informed choices of their prospective domain-specific careers. At the same time, the programme is also purposefully designed to integrate a natural fragrance creation project forged in partnership with the industry practitioner whereby the students are given opportunities to demonstrate autonomy in their creation approach to deliver the team-based project using the course-specified P4P with CDIO elements. Therefore in the subsequent workshops 5 to 8, students are progressively exposed to the creation journey, starting from understanding the Design Thinking framework, conducting market analysis for concept creation, stretching their potentials in innovating prototypes to presenting concept proposals that appeal to the mass markets. The scaffolding of the experiential learning is thus depicted in Fig. 3.

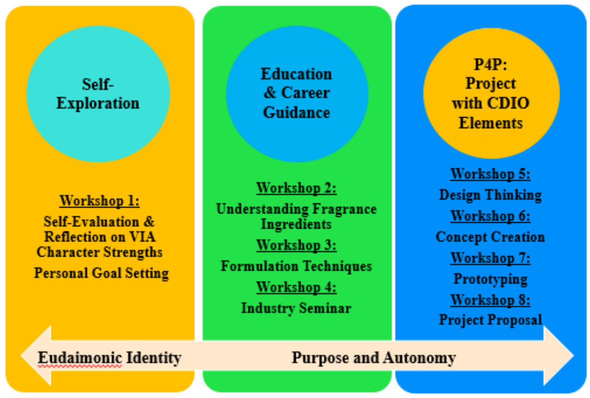

Fig. 3: Scaffolding of the EIPA(M) experiential learning.

Positive Engagement is facilitated by savouring physical pleasures of the gratifying experiences (also known as flow) and with mindfulness of the bite-sized tasks that are pitched to be manageable yet sufficiently challenging to dispel boredom in each workshop. In this way, the students are confident and focused in deploying their personal strengths and skills. Learning is further supported by mentorships rendered by the seniors. This form of peer learning aids in building a culture of Positive Relationships for growth, enjoyment and wellbeing. The seniors not only reinforce competency training using their prior course experiences but also provide a reliable source of support with empathy rendered on the concerns and challenges encountered by the freshmen. The freshmen, on the other hand, may feel a sense of security and belonging to the course community since connections make life purposeful. Significant impact of this sense of belonging on academic, psychological, social and behavioural outcomes have been previously studied (e.g., Allen et al., 2018; Helliwell et al., 2018).

The participants also embrace teamwork and collaboration which helps to heighten motivation. The seniors assume servant leadership to instill positive interactions while caring for the wellbeing and personal growth of the juniors. Next, Meaning stems from realising one's potentials in the productisation project (e.g. acquisition of mentoring and research skills by the seniors). Finally, Accomplishment comes in the form of personal growth with enhanced competency achieved during the project delivery on top of the valuable peer relationships forged as students journey through the experiences as a team.

Measures

Two sets of questionnaires are customised as the SDL measurements of construct with survey items adapted from a number of validated sources (e.g., Ryan and Deci, 2000; Dweck, 2006; Duckworth and Quinn, 2009): Intrinsic Motivation Inventory, Grit Scale and Growth Mindset Inventory. Ratings were obtained on a 5-point response Likert scale with the help of Microsoft forms. Table 1 captures an excerpt of the questionnaire items that are contextualised to the EIPA(M) learning journey and used in the pre- and post-intervention surveys.

Intrinsic Motivation
• I am willing to invest time in attending workshops for widening my horizon.
• My interest grows because of the trust and friendship established with my course mates.
Growth Mindset
• I am keen to have a good perspective of the industry related to my course of study.
• I am keen to learn about the use of design thinking framework required in the creation process.
Grit
• When doing the task, I am not easily distracted or lose interest quickly.
• I do not give up easily as I am not discouraged by the setbacks.

Table 1: An excerpt of the questionnaire that are contextualised to the EIPA(M) learning journey.

Results

For the purpose of testing the effectiveness of the intervention, the McNemar's chi-square (χ^2) test at 5% significance level ($\alpha = 0.05$; $p = 0.95$) is performed on the pre- and post-intervention survey responses. All $\chi 2$ values computed fall in 20-30 range which exceed the critical value of 3.841 (df =1). Hence by rejecting the null hypothesis, it can be concluded that there is a statistical difference in the number of students acquiring the three desirable SDL traits at the end of the intervention.

Although the five PERMA pillars are somewhat embedded in all the SDL attributes, some differentiation can be observed. Growth mindset is found to be more associated to Accomplishment, providing a direct positive predictor of achievement or mastery as students believe that their intelligence and talents can be enhanced through efforts and experiences. Grit, however, is found to be more associated to positive engagement since grit is defined as perseverance of effort and consistency of interest. Without positive engagement, it is difficult to sustain one's passion and persistent efforts. On the other hand, intrinsic motivation is greatly influenced by the establishment of positive relationships. When the students were further surveyed on the type of motivators that facilitate positive engagement, almost half of the reasons cited are relationship related, of which humanity factor (e.g., desire to help others and receive appreciations) constitutes 33% and social factor (peer influence) constitutes 16%. The remaining half is largely attributed by intrinsic factors of 38% (goals fulfilment, skills upgrading) followed by extrinsic factors of 13% (rewards, self-esteem affirmation).

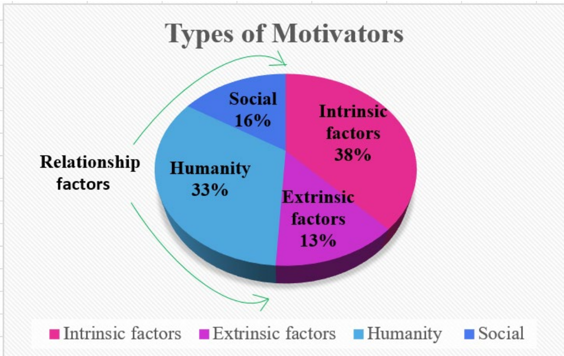

Fig. 4: Types of motivators.

With deeper insights, the Meaning pillar, on the other hand, can be interpreted differently in accordance to the role of the learning contexts. Despite demonstrating strong evidences of intrinsic motivation and growth mindset, some variation of emphasis is found among the participants. The junior's profile are comparatively high in growth mindset with moderate intrinsic motivation and grit while the seniors are relatively high in intrinsic motivation with moderate growth mindset and low grit (refer to Fig. 5).

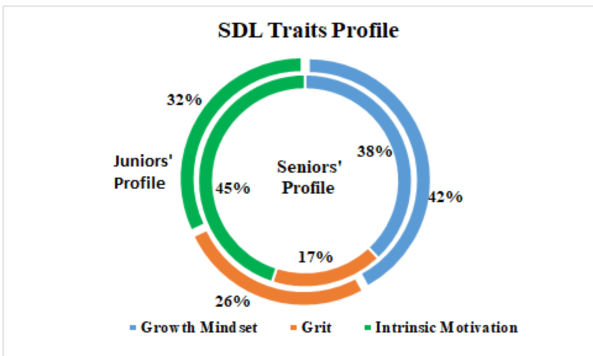

Fig. 5: The role specific SDL traits profile.

As a result of the differing learning context of the juniors and seniors, the goal set for each group would warrant a different set of the VIA character strengths in the course of cultivating SDL traits and supporting PERMA wellbeing. In fact, the relevance of VIA character strengths in the context of positive learning experiences (e.g. flow and enjoyment) and academic accomplishments have been reported previously (e.g., Karris Bachik et al., 2020; Wagner & Gander et al., 2020; Wagner & Holenstein et al., 2020). A survey conducted with the students on their deployment of VIA character strengths in the learning journey indicates two distinctive profiles (refer to Fig. 6). The junior's profile is skewed towards Wisdom (curiosity, love of learning), Courage (bravery, perseverance) and Temperance (self-regulation) with less emphasis on Justice (leadership, teamwork) and Humanity (kindness and love) whereas the senior's profile is skewed towards Humanity, Wisdom and Justice with less emphasis on Temperance and Courage.

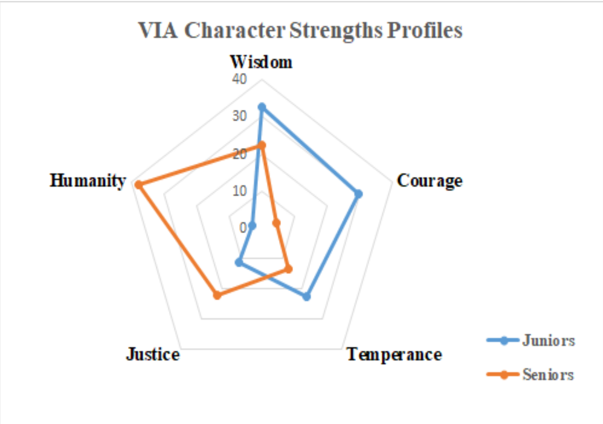

Fig. 6: Deployment of the VIA character strengths.

Finally, the overall rating improvements for each SDL attribute in the pre- and post-intervention surveys are consolidated and their respective Pearson correlation coefficients (r) at $p < 0.01$ for a two-tailed test are analysed. All the values seen in Fig. 7 are above 0.75 which implies a strong correlation among the three variables.

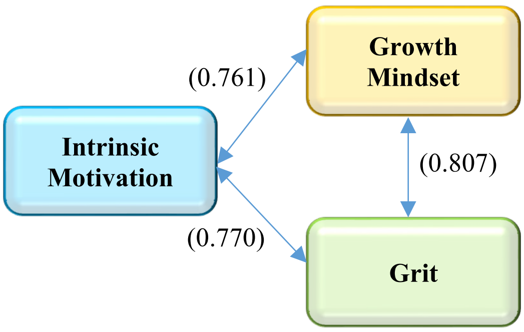

Fig. 7: The Pearson correlation coefficients (r) for the SDL attributes ($p < 0.01$ for a two-tailed test).

The positive associations of the three measurements of construct are further represented in Fig. 8.

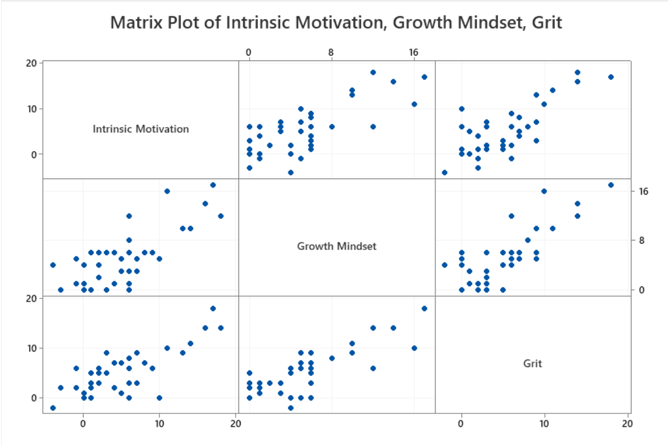

Fig. 8: The positive associations of the measurements of construct: intrinsic motivation; growth mindset and grit.

Discussion

It is critical to design PERMA-embedded activities that are aligned with one's personal inclination towards learning. In this way, the students are able to internalise the value of the EIPA(M) learning strategy to inculcate a positive mindset. The pursuit of an individual's mastery-oriented goal is believed to serve as the instrument that interconnects the SDL parameters as affirmed by past research (e.g., Park et al., 2018; Karlen et al., 2019; Schweder, 2019; Yu & McLellan, 2020; Benita & Matos, 2021). When individuals with growth mindsets set mastery-oriented goals, they would spontaneously make attempts to improve self-determination and self-regulation skills for the attainment of the goals. The success achieved will further motivate the individuals to seek more challenges while discover more opportunities for diligent and self-regulated practices. As noted previously, love of learning and self-regulation are the most frequently deployed VIA character strengths among the juniors. Since they have less exposure to the course and industry, their curiosity is piqued which makes their love of learning prominent, especially that they appreciate the incremental theory on the malleability of personal attributes through efforts. The self-regulation development can further be enhanced by the positive engagement derived from the joy of learning.

Grit is therefore associated with growth mindset as the individuals are not afraid of making mistakes or dealing with setbacks. The relatively high deployment of courage and open-mindedness in the junior's profile (refer to Fig. 7) seems to tally with this deduction. In addition to perceiving setbacks as essentials of growth integration, the shift in focus towards positive outcomes prompts individuals to take volition in problem solving during the project learning journey. As a result, growth opportunities are created for self-determined learning alongside with the cultivation of resilient attitudes.

A greater sense of SDT control over learning are prevalent in individuals who set mastery-oriented goals. Being passionate and intrinsically engaged, the individuals are empowered to upskill on current and relevant competencies with more grit. They demonstrate less tendency to give up in challenging circumstances. With deliberate practice, the individuals become more effective in their goal-directed actions and thereby develop a deeper sense of agency in autonomous and self-regulated behaviour. Having said that, persevering through the SDL journey is never an easy task which necessitates the synergistic contributions of the PERMA model of wellbeing. In particularly, Ryan and Deci (2014) postulates that relatedness is one of the key driver of motivated behaviour in the self-determination theory (SDT). Students are motivated when they are able to forge trusting and supportive relationships within an activity setting. It is essential for individuals to feel the sense of belonging, security and connectedness with the rest of the community in their mastery goal pursuits.

However, it is believed that the role of learning contexts may contribute to the activation of differential traits that are in response to the social environment and nature of the tasks to be performed. The expectations and behaviours of the students may differ as a result. For instance, the seniors fully appreciate the value of servant leadership, kindness and love which drive their intrinsic motivation in assuming the mentor role. They possess a strong desire to develop their juniors in the domain competency by leveraging on their prior course training. They are also open to explore new e-learning tools and design new activities for the online workshops during pandemic. Grit, perseverance and self-regulation are less demonstrated as mentors are not required to execute the project from the start to the end.

In a nutshell, Fig. 9 is constructed to illustrate the intricate interrelationship among intrinsic motivation, growth mindset and grit as well as the vital role of PERMA for the promotion of SDL culture.

Fig. 9: The proposed model for the PERMA-enabling SDL culture.

Conclusions

This preliminary study explores the positive impact of implementing PERMA model in the regime of self-directed learning. The infusion of positive psychology via the EIPA(M) learning strategy allows students to experience positive emotions, engagement, relationships and find meaning in their pursuits of personal growth with the course. The proactive intervention proves to be promising for nurturing the autonomous motivation of learning, growth mindset and grit in the individuals. The findings signify the potential value of integrating PERMA with the course pedagogy on Projects with CDIO Elements that is aligned with industry practices. The purposeful outcomes are further augmented by leveraging on personal VIA character strengths in the facilitation of individual's mastery-oriented goals. The building of the PERMA-enabling SDL culture in DPCS is posited to meet the demands of the INC curriculum and more importantly with a long-term objective to effect a transformational shift in the individual's positive mindset that is crucial in their lifelong learning journey.

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DEVELOPING A SUSTAINABLE STUDENT EXCHANGE MODEL FOR VPET WITH INTEGRATED AUTHENTIC LEARNING

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Abstract

It is critical in Vocational and Professional Education and Training (VPET) to provide students with relevant authentic workplace and practical learning experience. However, under the COVID-19 pandemic situation, the learning and teaching mode and learning environment setting was forced to transform digitally due to social and physical immobility in the past two years. For VPET, in particular, well-established experiential learning initiatives, such as internships in local or overseas workplace and international exchange activities, have been suspended or replaced, students were deprived of learning opportunities by traveling abroad or attaching at workplaces. VPET institutions had to reform physical exchange or attachment initiatives to reaccelerate the provision of relevant- and specific-to-trade's learning and to deliver in a more frequent and regular pace. In view of the situation, this paper aims at suggesting a virtual learning approach by digital tools under authentic problem setting. Adopting the existing virtual exchange models of curricular collaborative learning and intercultural online exchange as foundation, the approach further enhanced for real world work context and sustainable future deployment so that students can continue to acquire ready-for-work and necessary digital and transversal skills in the foreseeable period of mobility restriction, providing a complementary practical learning and digital work approach in the long run as "new normal" in parallel with what had been established and practising before the pandemic.

This paper provides a glance of the trends and needs in learning under the development and digital transition during the pandemic, and considers the virtual exchange model for implementation in 1) student exchange activities/events and 2) work-based learning with work attachments, taking the context of VPET in Vocational Training Council (VTC) of Hong Kong as the setting. The VPET-focused virtual learning model was proposed with specific emphases on thematic and project-based learning and authentic industrial-work contents in practice. The model was developed for virtual learning space or digitalised workplace in absence of face-to-face exchange, highlighted with students' engagement and connection with the industry and the global community, and students' learning of trade-specific and digital skills which also blends authentic and global work context into the VPET curriculum. The framework of the innovative approach is presented for future implementation, which also serves to upkeep international and industry partnerships and relationships. The implementation implications are identified and further discussed. VPET providers may take these into consideration when conducting and practising the approach.

Keywords: *virtual exchange, virtual internships, authentic learning, project-based learning, work-integrated learning, industry collaborations, internationalisation*

Introduction

With the increasingly interconnected business activity around the world, there is an accelerating demand for nurturing a talent pool for future social and economic needs through advancing a market demand- and economy-responsive VPET. Recommended by UNECSO and (International Labour Organization, 2003), policies and delivery of VPET should maximise and extend the involvement of and partnerships with organisations, industries and others in community, in local, regional or international dimensions, by enabling collaborations and knowledge exchange and benchmarking with international standards (Gregson & Allen, 2005), to groom future manpower with a global vision and awareness, communication skills to interact with people from diverse backgrounds, and adaptiveness to fast changes in the society. Close industry-institution collaboration facilitates internationalisation in institutions and the offering of learning opportunities which proximate to real-life work experience to learners to practice with real world contexts; it helps equip them with skills that are necessary for employment after graduation. According to Curtis & McKenzie, (2002) and McRae & Johnston (2016), these skills include multidisciplinary work-integrated knowledge on the latest technical developments, communication and

digital skills to work in globalised environment in different industries and countries.

Work-integrated and experiential learning activities include work placements, technical field visits, etc, delivered in the modes of project-based course work (Co-operative Education and Work-Integrated Learning Canada, 2021). Learners would be able immerse into work and industrial practices or an authentic environment for experience and interaction for deeper engagement and more relevant and effective learning on the spot or at the inter-exchange. Under the unprecedented pandemic where social distancing measures and restricted travel hinders physical exchanges, global exchange and communication for knowledge acquisition and networking has become stagnant with restricted physical participations, i.e. limited travelling or commuting for visits. With the extensive use of technology in education and business on a daily basis during the pandemic, it catalyses the work-integrated learning in virtual or blended mode (Bilsland, Nagy, & Smith, 2020; de Lucas Ancillo, del Val Núñez, María Teresa, & Gavrila, 2021). To develop and enhance students' competence in real conditions, it is important to upkeep their work-relevant skills and multidisciplinary knowledge; to maintain interpersonal touch for language and intercultural communication with people; to further enhance digital skills for 21st century workplace.

Virtual Exchange Learning Approach: The European Union (EU) has been promoting learning mobility and cooperation of students beyond language and cultural differences and across geographical boundaries learning exchange with counterparts outside of classroom. A virtual exchange (VE) programme EVOLVE under the Erasmus+ Project 2018-2020 was developed and implemented taking the advantage of the development of educational technology and the ease of use of digital communication tools. The programme initiated to engage young people for "technology-enabled people-to-people dialogues" in curricular learning by projects and intercultural sharing from discussions with peers in the region, by the use of online communication platforms in scheduled teacher-facilitated discussions (Evolve, 2022). In the model, participants were enabled to connect with peers to communicate instantly, exchange and learn virtually, without having to travel away from their base; thus reducing the cost and time but increase the efficiency for exchange. It can serve as a basis for virtual exchange learning in VPET as to compensate the loss or decrease of opportunity for physical exchange during the pandemic.

Workplace Digital Transformation: In adaptation to physical mobility, companies have taken on the challenge by changing the working mode, place-based working was no longer mandatory but with flexibility of hybrid working mode. Work interactions among remote workers have been enabled through online meetings and digital workspace platforms. Many sectors have entered a digital revolution in which the working mode will maintain with flexibility after the pandemic (de Lucas Ancillo et al., 2021) for its more cost-saving in terms of transportation and working space occupancy (Sethi & Caglar, 2021). To satisfy the needs for continuous development in the industries, it is crucial and effective for VPET students to acquire high level of digital competence, interpersonal skills and commands in language communication to accommodate for work in future workplace.

Adapting Changes in Learning through Virtual Exchange at VTC

The Vocational Training Council (VTC), Hong Kong has pioneered in the region in promoting VPET learning internationally through students' academic and cultural exchange and through work-related experience, and in organising—in collaboration with overseas partners—events and learning activities including international conferences and seminars, overseas exchange and workplace attachments. Since 2020, over 2,000 students per year participated in virtual exchange learning with partners from around the globe through a wide variety of interactive activities. Since the pandemic, these learning activities have been redesigned to adapt for physical immobility and have gradually transformed from physical mode to virtual mode, and to hybrid mode, using online platforms with digital technologies.

Existing VPET Virtual Exchange Model

At the VTC, an adaptive virtual exchange learning model based on the abovementioned EVOLVE project was introduced and adopted to promote internationalisation in students. The virtual model was first developed for VPET with collaborative project-based learning by engaging students in exchange without physical boundaries using digital tools and platforms, adopting student-centred learning with close supervision by teaching staff. It was adopted to compensate the dramatic reduction of physical student exchange opportunity during the pandemic situation.

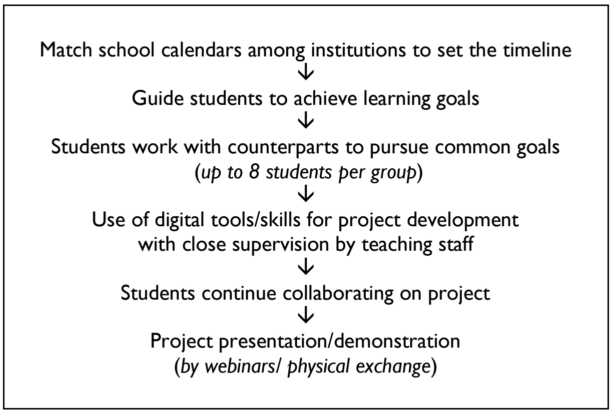

Figure 1 Adapted Virtual Exchange Model of the EVOLVE Programme at the VTC

Student Exchange Activities/Events

The VTC has been organising and coordinating a wide array of student exchange activities since developing internationalisation in its corporate strategies. Students from different academic disciplines participate in inbound and outbound student exchange and international exchange meetings of various scales with counterpart partners overseas around the year. In organising these activities, curriculum and project-based learning has been incorporated in the exchange to allow students to encounter real working and daily life experience of other countries throughout the semester period; it also began hosting large-scale international meetings in Hong Kong in 2010s, for academic and cultural exchange between students and staff (Lee, Wong, & Shimada, 2015).

Since 2016, VTC had organised International STEM Student Forum (ISSF) three times in four years, students from Science, Technology, Engineering and Mathematics related backgrounds from around the world for learning and cultural exchange. The event highlighted project presentations, students' forum, panel discussion by industrialists and cultural exchange activities. The programme featured project-based learning in the collaborative students' projects development through international arena. Collaborative learning through exchange was implemented which allow students to practise language and communication skills and share technical knowhow; hence, it could build confidence in students for future work development and create a platform for partners' bonding and institutional and industrial networking to take place.

Later in midst of the pandemic in 2020, the international student forum was organised over digital platform for the first time in VTC. Live joint technical project presentations, sharing and discussion on STEM project topics were conducted in blended mode (Mak, Lee, Tang, & Kwong, 2021), for local students and speakers, overseas students and guests. Despite the global challenges of the pandemic, with support of the Education Bureau of the Hong Kong Government, the forum attracted over a hundred of participants from 10 institutions in 7 different countries and regions, synchronising participants virtually in their respective countries with the physical venue in Hong Kong.

From the preparation through the event, digital technologies were utilised by means of online meetings and digital compilation of project work to facilitate the exchange; the example of ISSF 2020 demonstrated well how online interaction and engagement could still effectively promote technical communication among students while enabling supervision from teachers, and it further enhanced students' digital competence through the VE. Apart from conducting student exchange activities by online mode, it also enriches with thematic exchange for different solutions across the countries. With teacher's participation in curriculum design and programme delivery, teaching staff also benefit from the exchange activities, which serves as a continuous development for staff. It also aligns with modern VPET trends in life-long learning for teaching staff to exchange and learn the ways of other countries. With the support from Government, industry, management and staff in institution, the international student forum demonstrated a good example for shifting the large-scale international event to a VE approach for students and staff to maintain the collaboration and connection with the world.

With continued restrictions in physical travelling, the student exchange activities also adopt virtual mode managed under a shorter cycle to encourage more frequent student exchange. Series of online exchange activities includes trade specific learning workshops, innovation workshops and competitions, where students from two to three institutions of the same or different faculties or academic disciplines are grouped together to collaborate and develop products or solutions to solve problems encountered by the industries and finally to present their innovative and practical solutions over online platforms.

Learning goals of the approach usually include at least one or part of the course or module's continuous assessment(s) that spreads over the duration of one semester. Students are required to present their project solutions or outcomes based on their knowledge learnt or sharing from the perspectives of their respective countries. While the project can be developed according to the curriculum matched on each side, it is preferred to have joint elements to collaborate for multidisciplinary learning which would be achieved by careful design of learning content and guidance from teachers, thereby encourage students to interact and build fellowship in learning and in friendship on the other side.

Among the extensive VE activities, the Greater Bay Area Student Exchange Alliance jointly formed by VTC and Shenzhen Polytechnics, China was an example to gather students for VE learning (Mainland and International Affairs Office, Vocational Training Council, 2022). Themed smart city, technology innovation and entrepreneurship, series of activities consist of virtual student exchange, virtual tours/company visits, webinars and student project showcases were organised from 2020 yearly. The series of activities are also enriched with industry elements where experts, industry practitioners and entrepreneurs are invited to share the latest industrial and career development experience to students to prepare them for their future careers.

Problem-based learning is another innovative pedagogy to consider in the VE model for VPET learning, to provide opportunities for students learn by tackling real life challenges, it promotes students in intellectual thinking, problem-solving, teamwork and creativity by

motivating them to discover problem and discuss and explore solutions (Novalinda, Giatman, & Fajra, 2020). An intensive idea exchange event “Ideathon” was organised by the National Institute of Technology (NIT), Kumamoto College, Japan in September 2021. Around 50 students from Hong Kong, Japan and Thailand were divided into groups of 6-7 students to discuss, conduct research and design technical solution in presence of a real-world problem in the two-day exchange programme. Guest speaker shared the development of research and industry technologies and taught the approach for the technical design, followed by outcome presentations. The Ideathon experience stresses in-depth thematic student exchange and encourages students to adopt problem solving skills to solve real problem with peers from other countries. The next Ideathon Challenge to be organised by VTC in 2022 is planned with a theme on sustainable development, with virtual visits guided by student counterparts to explore the real-life practical problems encountered in the other countries, and a more specific focus on industry elements and involvement with community projects sharing to inspire students for creating ideas and building practical solutions with technology.

Work-based Learning by Virtual Internship

For work-related experience, it offers to students authentic learning opportunities through international internship or workplace attachment programmes in companies for about one to two months. Taking reference from successful work-based learning models of virtual internship shared by A. R. Medeiros, D. Ìcen, E. A. Morciano, & M. Cortesão (2015) and Bilsland et al. (2020), traditional internships also have taken the VE approach in VTC during the pandemic, industry elements and professionals’ facilitation were also integrated.

The internships are arranged in virtual mode for remote work at companies in Hong Kong, Thailand, Sichuan and Guangdong of Mainland China, etc. While the same principle is applicable in different locations, students are to use digital tools to communicate and complete daily tasks assigned by companies via online platform. Fields of jobs includes IT programming, multimedia design, marketing and advertising, e-commerce, product design, fashion design, etc. During the internships, students can intensively practise their different software skills and online communication skills for application in real-life work contexts. Although the internship is conducted in virtual mode, it provides the practice of a new mode of working which is expected to be a new trend in the industries and seen as a new normal in the post pandemic era.

Other than the job practice and on-the-job training itself, from students’ feedback in 2021, it was most valuable and helpful that professionals or mentors from companies provided timely feedbacks on students’ work performance and on their soft skills practices. Cultural activities by virtual visits and networking gatherings with overseas co-workers are also organised on some weekdays and over the weekends. So apart from enrichment of industrial and real work exposure, this kind of work-based activities can also create potential employment opportunities for student interns after their graduation. Therefore, it is recommended that institutions keep close partnerships with industries where companies would be devoted to offering quality internships and more networking opportunities, providing meaningful inputs to nurture and facilitate students for work practices and future career development, and which in turn would fuel quality manpower and talent for the industries. Hence, it is important to maintain these networks for collaboration of these activities in the industry during the pandemic; by conducting this virtual approach, it can achieve sustainable institution-industry partnerships.

Discussion

New Teaching Initiatives

The enhanced model facilitates the shift of traditional teaching and training by instruction to student-centred learning by adopting a focus on experiencing authentic problem context and industry practices, where students learn with the guidance from teachers or professional mentors. According to the study of EVOLVE report in 2020 (Nissen & Kurek), teachers are also motivated to innovate and enhance different pedagogic approaches; they can evaluate the feasibility at low cost and at faster pace cycles under digitalisation, with more students to participate. The advancement of digital tools such as Artificial Intelligence (AI) can also be implemented to help the training and assessment of the exchange activities; thus benefiting learning and teaching more extensively.

Industry-oriented Manpower Development

Emphasising industry collaboration, the innovative approach makes learning and teaching relevant by addressing the needs in the industries and the job markets and by incorporating thematic and authentic work contexts. Under the trends of digitalisation, companies are also evolving their workplaces and operations into digitalised platforms with technologies such as remote communication, Internet of Things (IoT) and automation. Adopting the VE approach can enhance student’s digital literacy, communication and presentation skills and other transferable skills, to equip them with acumen on industry updates. It also addresses to strengthen industry partnerships on manpower development, to provide the most relevant VPET to students for future career development and nourish them to become highly competent leaders for the future workforce.

Global Perspectives of Students and Staff

By designing contents with multi-countries perspectives and encouraging students from multi-countries to interact in mixed groups, it extended students and staff's development to learn about the world market, this will train up students to prepare them as global citizens, it is also beneficial to teachers to learn about different approaches and solutions from other countries, they can then develop their curriculum and teaching approach with enrichment of knowledge learnt through the exchange.

Through the VE, it also provides incentives for institution to continue and maintain close international collaborations and technical exchange with overseas institutions and industry partners during pandemic.

Implementation Implications

There are several factors to be considered for implementation:

1. For effective delivery in exchange, although there is limitation in time zone differences when grouping students with other parts of the world for live meetings, it is still best, where possible, to keep a larger proportion of time for online verbal communication conducted in real-time rather than by text communication for the best outcomes in interpersonal exchange. Besides, the number of students per group should not be too large—while the smaller the better for deep exchange and interaction, it is recommended to keep the number at up to eight. Also, for better management for executing blended mode on site, it would be better to keep students in a premise or dormitory space for group projects development.

2. Some work contents are still not suitable for collaborative VE by nature: place-based, in-person or hands-on work in some procedures and functions in the fields of engineering, culinary art, hospitality and caretaking may not be possible. However, with the advancement of technology, in the future, physical contact may be substituted by new systems, applications, approaches that do not require such exposure. As such, students have to always prepare for adapting to disruptive technologies that may emerge in the future industries, and keep themselves updated for global changes.

3. It is difficult to arrange deep level of cultural exchange by online mode. With advancement of digital tools, virtual visits and tours and tailormade activities should be further designed as complements to the thematic VE learning to provide a holistic international exchange experience. With VE learning being delivered at faster pace, it increases students' opportunity for learning through exchange and work experience, and can be treated as an advanced course under the physical restrictions.

4. For large-scale event-based VE activities which require joint effort of a considerable number of students and staff members from hosting and participating institutions and organisations, and long period of preparation time. Depends on financial and manpower resources and support from stakeholders, it usually could be organised up to once or twice a year. However, with much fewer resources drawn compared to organising large-scale physical events, virtual and hybrid events are still considered a new trend.

5. Teacher or industry mentors' role is of high importance when designing the learning goals in the virtual learning or work contents and when facilitating students for project development or internship, for a smooth online exchange and discipline management. Provision of training of teachers to lead and facilitate VE on a scheduled pace and preparation for students' knowledge, skills and manners for global communication and work is needed. Evaluation and assessment of learning outcomes can be further implemented in later research.

Conclusion

This paper suggested an enhanced VE model as an alternative or complementary solution to physical exchange owing to the pandemic conditions. With the shift to virtual platform, students can learn and gain authentic experience with thematic real-world contents, under the facilitation by teachers or industry mentors, to tackle real-life problem through project- or problem-based and work-integrated learning in the spectrum of student exchange activities, events and virtual internships. Teachers continue to play an important part to design and facilitate students' learning and exchange for maintaining up-to-date global and industry development in learning and teaching. As fewer physical preparatory resources and shorter lead time for preparation are required; more students can be accommodated and benefit from the participation.

It is also significant for VPET institutions to keep close global network and industry connection during pandemic situation to provide relevant real-world contents in VPET and in the continuous manpower development, and to prepare for blending in the workforce and development in the post pandemic era, thus bringing forward a sustainable model in hybrid mode for future VPET.

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Educating Future Female Seafarers in the Maritime College from Perspective of Masculinity and Androgyny

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Abstract

The idea of stereotyping social roles based on gender persists, and gender is a major factor in employment. One of the most prominent examples of this is the "seafaring industry. Recently, the Maritime Bureau and Seafarers Policy Division of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) have been working to promote gender equality in the seafarer industry, and in 2017 launched the "Committee on the Promotion of Female Seafarers' Activities from a Female Experts' Perspective" to discuss the issue. I participated in this committee as one of the three academic experts. What has been reported from the committee was that the percentage of female seafarers in Japanese shipping industry was only 2%, and less than 10% of shipping companies showed a positive attitude toward the employment of female seafarers, indicating that the employment of female seafarers was not being promoted. On the other hand, nearly 70% of female students at maritime colleges have expressed their aspiration to work as seafarers, so it is essential to improve the working environment, and it is also important to ensure that female students who are employed by shipping companies remain employed as "female seafarers" for a long time after marriage or childbirth. The purpose of this study is to train female students in maritime college so that they will be able to work as seafarers with leadership skills in their future. This study also aims to activate women's education in maritime colleges, promote the activities of female seafarers in the maritime industry, and achieve gender equality in the maritime industry. A unique aspect of this study is focusing on "masculinity studies." It demonstrates through the workings of female seafarers that seafaring should have "diversity," and brings out the "masculinity" and "androgynous" in women to foster female seafarers who can play an active role in the shipping industry.

Keywords: *female seafarers, gender consciousness, shipping industry, career development, maritime education*

Introduction ～ Literature Review ~ Female Seafarers in History

For centuries, maritime history has treated seafaring as a male domain. Although a few women have been recorded as having travelled as stewardesses, explorers or as companions to captains, on the whole women did not take part in the actual running of ships. It was not until the steamship era around 1900 that women began to be systematically recruited as crew members aboard passenger ships. There are other cases of women having served during the Second World War, mainly as radio officers aboard Allied ship. The former Soviet Union is an extraordinary anomaly. Reportedly, as many as 8,000 women served on the country's ocean-going merchant vessels and 21,000 on vessels employed in inland navigation during the Second World War. These women may have been exceptional, but they also showed what women could do when given the chance.

It was not until the post-1945 period that women began to appear regularly as crew members aboard cargo ships, most often on Swedish ships as stewardesses, cooks, and radio officers. Moreover, at about the same time, Chinese women seafarers crewed the world's first women-officer-only cargo ship, which traded in international waters. From the mid-1980s and for a period of about 15 years, the shipping world lost interest in recruiting women. it was around in 1990 that again women recruited as seafarers, because the industry began to experience serious difficulty in recruiting men as seafarers. So since the late 1990s, there has been a growing interest in training and recruiting women seafarers, which was largely connected to perceived shortages of officers in the world fleets. As a resolution to this, the IMO (International Maritime Organization) produced a strategy for integrating women into the maritime sector in 1988, whose purpose was a concentration on equal access to maritime training through both mainstream programs and gender-specific project. One of the immediate impacts of this program has been the rise in the percentage of women students made up less than 8 per cent of the total number of students at the World Maritime University in Sweden. However, unfortunately this trend could not be regarded as a general settlement. After that, the IMO produced some programs for recruiting women in maritime sector, but overall, the

participation rate of women in seafaring remains low. It has been estimated that women represent only 1 to 2 per cent of the world's 1.25 million seafarers and that most of these women are from developed countries. Among a group of eight European countries (Belgium, Denmark, Finland, Germany, Italy, Norway, Sweden and the United Kingdom), the average proportion of women in the total seafaring workplace was found to be 9.15 per cent, although the relatively high numbers of Swedish and Danish women and the very low numbers of Italian women seafarers seriously distort this average.

1. Analysis of Female Seafarers' Conditions in Shipping Industries in Japan

I consider a situation of shipping companies' attitude towards women seafarers in Japan. I examine the policies of some companies which determine the shape and character of the labour market for seafarers. Unfortunately shipping company in general do not have specific policies relating to women seafarers. There are no policies against employment, but in some countries shipowners can tend to be very negative regarding employing women at sea. This is more evident with shipowners that have never employed female staff before. In some cases, distinctions are made between what is considered appropriate for women seafarers, with some shipowners indicating a few posts where they would never employ women, such as bosun or chief engineer. However, shipowners used to employing women at sea, irrespective of the positions they hold, have, in general, no complaints. Indeed, many of them highlighted the fact that women seafarers can be extremely hard workers. Most cruise companies have sexual harassment policies, although they are not specifically designed to address women seafarers. In most cases, cargo companies have no such policies in place. pregnancy and maternity leave are, in general, non-exist.

Moreover I carried out a survey with about one hundred domestic shipping companies in Japan last year. This survey was conducted to investigate several difficult problems regarding the employment of women seafarers with these companies. The research method was my giving the companies a questionnaire on a visiting survey and a follow-up interview by telephone. All the data were analysed, but company names should not be identified, at their requests.

There are over three thousand domestic shipping companies in Japan, most of which are tiny businesses. Among the companies I examined, only five employed women as seafarers, but one of them has women seafarers just as deck officers, which is a company rule. Most companies, except these five, are unwilling to hire women seafarers.

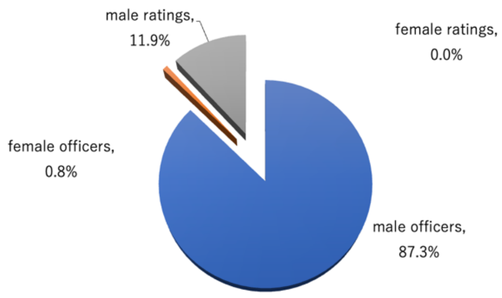

Figure 1: Distribution by rank and sex in the Japanese International Shipping Industry (Cargo ships)

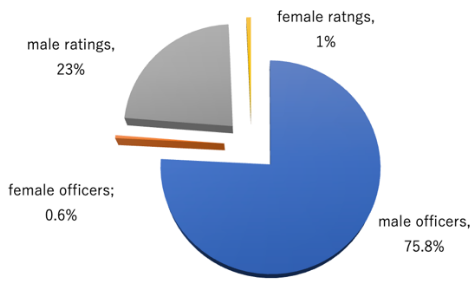

Figure 2: Distribution by rank and sex in the Japanese Domestic Shipping Industry (Cargo ships)

As described above, these graphs show the distribution by rank and sex in the international shipping industry as well as in the domestic shipping industry. As is apparent from these graphs, women seafarers in Japan comprise a very small number. I shall examine the reason for this. Please note the graph given below:

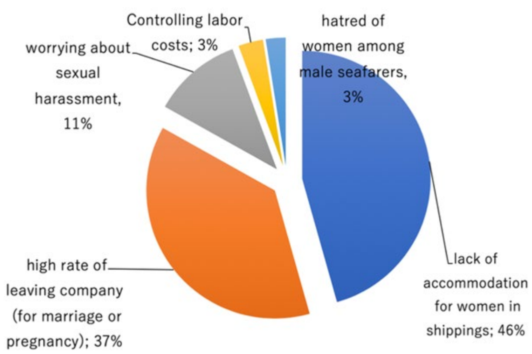

Figure 3: The reason for the unemployment of women seafarers

This graph shows the main reasons for the unemployment of women seafarers in Japanese domestic shipping companies. The most important reasons are the company's small size, so that they cannot afford to provide facilities for women on their ships, and they cannot to afford to give women any training because of a reduction in the workforce. In addition, many of them

have strong reservations about the difficulties that may be caused by sexual harassment. In the Japanese shipping world, there is a considerable disparity between the international shipping industry and the domestic one. I got the impression from my survey that among various types of occupations in Japan, there is no occupation with such a considerable disparity in the status of workers than seafaring. In some international shipping companies in Japan, seafarers, as well as employees who are on shore duty, are supposed to get onto the elite track, getting higher education, all of whom receive an upper grade certificate of competency in seamanship after their graduation from college, university, or post-graduate school. The three biggest companies in the Japanese international shipping world, NYK, MOL, and K-Line, have several women seafarers because of their policy to employ at least one women seafarer a year. It was NYK that came up with the first strategy to hire a woman deck officer in 2003, and after that, all three of the biggest companies have continued to employ women officers as both mates and engineers. Administrators of these companies declared that they were never conscious of gender differences with their women colleagues, and they emphasize women's abilities regardless of gender.

However, male seafarers who worked at the small domestic companies can be said to be so-called blue-collar workers, getting only a low level of education and a lower class license just for domestic shipping. The smaller the company, the truer this is. So it would seem that people in international shipping companies are endowed with views of gender equality so that they see their women colleagues as seafarers, not as women. But people in the domestic shipping companies, except a few, seem unable to adjust to the idea of gender equality so that they recognize their women colleagues as women, not as seafarers. I think that, generally speaking, uneducated and uncultured men tend to have sexist thinking towards women in their workplaces. Although I have no idea whether they will have problems with sexual harassment or not after hiring women as seafarers, personnel managers may worry too much about potential problems that may never exist.

Moreover, we should note that companies raise the high rate of leaving the company for marriage or pregnancy as a reason for the unemployment of women. Regrettably, it is true that most Japanese women tend to quit their jobs after marriage or pregnancy. It may be surprising to learn that in Japan most women dedicate themselves wholly to being housewives after marriage. Irrespective of the type of work, it causes losses to companies that their workers give up their jobs after being trained. This is especially true in the shipping industry, which is regarded a distinctive domain. The smaller the company, the more they will suffer financially. Considering this, it is natural for companies to avoid hiring women. Most companies I investigated demanded that women employees stay at least three years, while admitting that most women are excellent and motivated when entering the company. Considering this, the responsibility rests with women, because it suggests that women have a weak sense of professionalism.

On the other hand, I could mention the reason why the five domestic shipping companies hire some women seafarers. Please note the graph as follows:

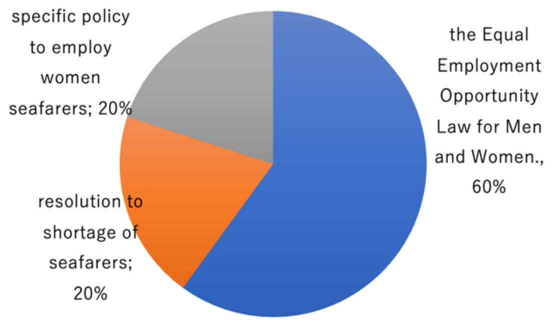

Figure 4: The reason for the employment of women seafarers

This graph shows the reasons for employing women seafarers from the five companies I investigated. I cannot deny that the main reason women are hired is the Equal Employment Opportunity Law, although some companies are still unwilling to hire women. The next reason is the shortage of seafarers in Japanese domestic shipping companies. A senior management director told me that they want very much to hire talented male seafarers but, even suffering from a labour shortage, they are unwilling to hire women as seafarers.

Interestingly, among the companies under my investigation, three companies have female presidents, one of which employs women seafarers. A specific policy to employ women seafarers was given by this company as the reason. But the presidents of two other companies strongly rejected hiring woman seafarers in spite of their own gender. They insist that seafaring is very hard profession, therefore women are unqualified for it. As I referred to earlier, compared with the international shipping industry, the domestic one is harder. As for the international one, there are many ratings in ships, so officers do not need to be jacks-of-all-trades, but in domestic shipping, there are only four or five positions without distinction between an officer and a rating.

I mentioned earlier that seafaring is not dominated just by men. The reason I believe so is that there were so many women seafarers in former times when motor-powered sailing vessels were enormously helpful in domestic shipping in Japan. It could be said that the Japanese domestic shipping industry was supported by motor-powered sailing vessels in former days. At that time, the business was so small, and most were family operations, so-called family ships. Ship owners had their wives on board to control labour costs. In 1950s and 1960s, family ships navigated by women had a surprising increase in number, meaning that domestic shipping in those days was maintained by the activities of women. Nevertheless, today women seafarers in the shipping

industry have been a minority for the several reasons I have mentioned. I concluded that there are vast differences between women seafarers in former times and those of today. The former was the person on whom the family depended for financial support by being on board; the latter regards her job as temporary until marriage.

There is crucial difference between seafaring and other traditionally male jobs, namely that women seafarers are required to work away from home for extended periods. It is certain that this causes particular difficulties for a woman continuing her seafaring, although absence from home can be problematic for all seafarers. As a result, most decide to quit their jobs after marriage.

2. Educating Future Female Seafarers in the Maritime College from the Viewpoint of Diversity, Masculinities, and Androgyny

The reason for this is not only that there are problems with onboard facilities and women leaving the workforce due to marriage and childbirth, but also that there are many shipping companies that do not see the value in hiring women because of the stereotype of seafarers as "masculinity. However, there are more than a few shipping companies that do not value the employment of women because of the stereotype of seafarers as men. How did such a notion become entrenched? The problem of ideology is not an economic issue, as in the case of renovating onboard facilities, etc., but requires a fundamental change in attitudes towards gender equality.

I thought the key words there were "androgyny" and "masculinity."

Since previous eras, nowhere has masculinity been as articulated as in the world of ships. The masculinity of men who sail the oceans, even among men, has been constructed in contrast to that of men who live on land, much less as the opposite of women. In other words, the masculinity of seafarers has been formed with "what women cannot experience" at its core, such as the unique life on board a ship.

However, the latest masculinity study suggests that "masculinity" is not necessarily unitary. For example, R. W. Connell, in addition to referring to the plurality of masculinities, focuses on power relations that arise from gender by defining hegemonic masculinity as a form of masculinity. There are two agreements behind Connell's treatment of masculinity as a plural form. First, gender is constructed differently in different cultural and historical contexts. Based on his recent research results, Connell concluded that there is no universal form of masculinity. Therefore, it is necessary to recognize masculinity as a plural form, not a singular one. Second, multiple forms of masculinity coexist even within the same period and society. As the interplay of gender, race, and class was discovered, the perception of multiple masculinities became widespread.

Androgyny, on the other hand, is a distinct sense of self in relation to cultural definitions of masculinity and femininity, and a self-concept that is completely inconsistent with what is culturally defined as gender-appropriate. The idea that men should be masculine and women feminine was rejected, and it was argued that it is desirable for men and women to be able to take on both roles according to the situation, regardless of gender. It is believed that a person can have both masculinity and femininity in him or herself, and such a state is called psychological androgyny.

The concepts of masculinity and femininity are influenced by society's perception of ones, but there is insufficient data on how women involved in jobs that were originally perceived as male occupations perceive their femininity.

Keeping in mind the gender consciousness in the shipping industry as described above, this study focused on the "diversity" of seafarers and enlightened female students of our college by surveying the current activities of female seafarers in the shipping industry.

This study was conducted not only for female students, but also for male students, with the aim of encouraging students to become seafarers with leadership skills in the future, regardless of gender, in the maritime industry, where gender stereotypes are strongly rooted. The study also found that the following points were made clear through the exchange of information among female faculty members of maritime college:

・It is important for seafarers to have the flexibility to listen to the opinions of others. As is true for all professions, communication skills are extremely important, especially for seafarers, who live together on board for long periods of time.

・The fact that female students lack arm strength is understandable, but in recent years, arm strength has not been a requirement for both men and women on many types of vessels. The important thing is not to run away from something because you cannot do it from the beginning, but to give it a try anyway. It is important to experience everything, regardless of gender, and to develop one's own areas of expertise. This also applies to male students. Even if female students don't have the arm strength, they can work as a seafarer without any problems at all.

・Few men or women work on board for the rest of their lives. This is because work at sea and on land is alternately assigned at intervals of a few years. When managing vessels and seafarers on land, it is a human-to-human relationship. In other words, it is necessary to develop the ability to manage with an understanding of the situation on the ground. Regardless of gender, it is necessary for seafarers to acquire the ability to work not only as seafarers but also as land-based workers, in other words, the ability to communicate and make good judgments.

Interviews with female seafarers in active service and shipping companies revealed the true feelings of shipping companies toward the employment of female seafarers and the current situation of female seafarers. While it is gratifying to see that more and more shipping companies are stepping up their efforts to hire female seafarers in light of the growing awareness of gender equality in the

shipping industry, it is clear that most of them are at a loss at first. After all, the crucial difference between men and women is that women are always faced with the problems of marriage and childbirth. The main reason is that the ideologies of "patriarchy" and "division of labor" still persists. In societies where these ideologies have taken root, women who are responsible for domestic labor are restricted from economic activities outside the home, and men who are responsible for work outside the home are restricted from engaging in domestic labor. Today, more and more men and women are becoming resistant to the division of roles based on gender, and more and more men and women do not form the organization of a family. What has become clear through this activity is that today we must deconstruct the concept of gender role division of labour. Of course, men and women who do not feel uncomfortable with the system of gender role division of labour can do so, but this should be a choice among various ways of life, and gender should not be the standard for all.

Finally, through this study, we enlightened female students on two major points: First, it is important to plan one's life in the long term if one is to live as a seafarer. Women are likely to experience major life stage changes, such as marriage and childbirth, and it is therefore important to find a job with a shipping company that will allow them to return to seafarers' employment without leaving the register when such changes occur, rather than quitting seafarers' employment altogether. Another point is that "seafarer-ness" is not synonymous with "masculinity" and "androgyny.". For female students who aspire to become seafarers in the future, it is important to dispel the stereotypes they have had up to now and ask themselves, "What is the masculinity that is unique to women? It is essential for female students who want to become seafarers to form their own image of what they want to be as seafarers from the time they are students. This will be an important key point when pursuing career development as a seafarer in the future.

3. Conclusion

For the same academic ability and skills, many shipping companies often seek out boys, not because girls are inferior, but because the companies are not accustomed to hiring girls and are anxious to do so. However, the survey in this activity revealed that, other than arm strength, there is little gender difference between men and women in, for example, knowledge and judgment. Ultimately, this does not mean that women are less capable as seafarers, but rather that women tend to be excluded by the stereotype of "seafarer = male. What is important is to keep in mind the seafarer culture and the values unique to seafarers that have been created over the long history of seafarers, and to devise ways to create a "new seafarer culture" and a "new image of seafarers" that can promote the success of female seafarers from many angles.

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SELF-DIRECTED RESEARCH (1):AN OVERVIEW OF CURRENT APPROCHES

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Abstract

Student-research program has become more and more popular in high schools in Japan. It is now in the regular curriculum in high school. The college of the authors introduced this kind of student-research program more than seven years ago. We call our program the "self-directed research program," since it is very different from other student-research programs of high schools in Japan. Generally, high school students choose the themes, implement experiments or observation and write the reports under the strong direction of teachers. Students at our college have been doing differently. Students must find their themes, accomplish the experiments or observation and write the final reports all by themselves. Besides, they can research anything as long as the research is done in a scientific manner.

In order to make the self-directed research program work effectively in our college, we changed the curriculum drastically in 2015. We cut one fourth of the total hours of lectures. All the lectures were given in spring, summer and winter terms, while autumn term was set entirely for the self-directed research activities. We call our schedule "the four-term system," for it is very different from other school year systems consisting of four terms.

The self-directed research program and the four-term system have been changing after it started seven years ago. As for the self-directed research program, the ways of supporting younger students changed as follows. When it started, the instructors, called coordinators, help students if necessary. Then, one coordinator began to have classes where students talked with classmates under the guidance of coordinators. We call this class the student peered discussion. Now, senior students, called "facilitators," help the younger students extensively throughout the year.

As for the four-term system, it changed as follows. When it started, no lectures were given in autumn term and students were asked to concentrate on their research. Soon after, some lectures were introduced in autumn term. In 2020, due to the spread of covid 19, lectures were given in all terms, with relatively less lectures in winter term. Students could have enough time to finish their research. They made their presentations in winter.

Our program has been advancing a lot since it started in 2015. We found some problems which remains to be improved and a success which was obtained beyond our expectation.

We mainly discuss the self-directed research program for younger students. This is because the program for senior students has changed to a part of the graduation research after 2018. All the authors except for the first one were coordinators in recent years, while the first author was the head of the four term system.

Keywords: self-directed research, facilitator, experiment, theme, senior student

Introduction

Before 2015 it had been said that Japanese students were good at solving the problems of which the standard solutions were given by the teachers, and they were not good at thinking the problems by themselves. Under this circumstance, the education ministry introduced the super science high schools (abbreviated SSH). Some high schools began their own student-research programs. Among these high schools was Horikawa high school in Kyoto.

Horikawa high school was an ordinary high school until it started the "tankyu-kiso" program in 1999. Tankyu-kiso can be translated as the fundamentals of research. This program consisted of one and half years form the entrance to the high school. It consisted of three processes. The first six months were the period of "HOP." Students learned how to find the themes, how to investigate the problems they chose, how to consider logically, how to write reports and how to make the presentations. The next six months were the period of "STEP." Students were divided into small groups and learned the ways of research in these specific areas such as mathematics, physics, chemistry, biology, information, literature, social study and international culture. The final

six months were the period of "JUMP." Each student set his or her own theme and researched it by oneself under the direction of teachers and teaching assistances who were the graduates of Horikawa high school. Then, they gave their presentation in front of the audience that consisted of teachers, classmates, teaching assistances, and guests from universities. Usually, students were given critical comments from the audience. Surprisingly, those severe comments did not let the students down. Rather, they motivated the students to make their researches better. After the presentation was over, students advanced their research, and submitted the final reports. This completed the student-research program of Horikawa high school.

After introducing this program, excellent junior high school students in Kyoto began to apply for Horikawa high school. Soon it became one of the top high schools in Kyoto. Now, many graduates of Horikawa high school enter excellent universities such as Kyoto University, and many of them become the teaching assistances of Horikawa high school. The program of Horikawa high school has been working so effectively that it made the school very famous. People called it the miracle of Horikawa high school. There are many web sites introducing the success of Horikawa high school. We list one of them in the reference.

Inspired by the success of those high schools, the college of the authors decided to begin the program "self-directed research" in 2015. Our program was very different from those of high schools. We will explain the details in this paper.

Implementation in 2015

Student-research programs in high schools are regular curriculums. Students study for one or two hours once a week for this program. On the other hand, students in our college had no regular lectures for this program. They concentrated on the research in autumn term without studying usual subjects such as mathematics, English or Science. They made their presentation at the end of autumn term in front of the wide variety of audiences, including students of other grades, gests form other institutions, parents and the instructors of our school in the gymnastic hall. Good presentations were awarded by the votes of the audiences. Picture 1 and Picture 2 show the scenes of the presentations in the gymnastic hall.

In order to make this program work effectively, our school had to change the curriculum. Most of the subjects were of more than one credit and they were divided into one-credit subjects. Half of them became so called "gakushu-tanni" subjects. A subject of gakushuu-tanni consists of lectures of fifteen hours per credit, while other normal subjects consist of thirty hours per credit. This change cut one fourth of the total hours of lectures. We called our own system "the four-term system." In this system, spring, summer and winter terms were normal terms when students studied the usual subjects, while autumn term was the period only for the self-directed research.

Some instructors were assigned as "coordinators." Some authors of this paper were assigned in this year. They supported the students. Two coordinators were assigned to each class that consisted of about forty students. The coordinators had two jobs. One was advising students and the other was the evaluation of the research. They were expected to give advice when they thought it was necessary. But one very enthusiastic coordinator began to have regular hours for discussion in a class. Students could earn one or two credits for this program.

The themes ranged over wide areas such as physics, music, entertainment, food, plants, insects, health, environments, cosmetics, and so on. One of the excellent researches was done by a student who observed the habitat of squirrels living in the gardens of our school. The evaluation was made in accordance with the specific rubric made for this program.

Picture 1. The poster presentation in the gymnastic hall

Picture 2. A student is explaining his research to a student

Small changes in 2016

In 2015, the self-directed research was not mandatory, and students had no classes in autumn term. Although our college encouraged the students to try the research, some of them did not. Many students made great efforts at pursuing their research and wrote good reports, and some of them received awards in the contests outside of our school. On the other hand, some students stayed home and played games. Parents complained that students were

wasting time at home without doing anything good. They asked the school to let them go to school to study.

In 2016, the program was changed to be mandatory to all students. It was determined that students must urn at least one credit of the self-directed research to proceed to the next grade. All classes of the first graders adopted the regular hours of discussion initiated by the enthusiastic coordinator. These classes were called the "student peer discussion," abbreviated SPD. Picture 3 shows a scene of SPD.

Picture 3. A student is making a presentation in SPD

In this year, the intensive mathematical science classes and intensive English classes were introduced in autumn term, although they were not mandatory at that time. These changes made many students come to school in autumn. Besides, even some extra classes such as history, literature, mathematics and technology were also introduced after winter term. The credits of these extra classes were given to the students in the next school year after the student proceeded to the next grade. The curriculum became rather complicated.

Big changes in 2018

In 2018, the curriculum changed again. The extensive mathematical science classes and the intensive English classes in autumn term became mandatory to all the students. Some other ordinary classes were introduced in autumn term as well. The program for senior students changed to a part of the graduation research. They were to study the themes given by their supervisors. So, the self-directed research program split into two programs. One was for younger students and the other was for senior students. Younger students could choose any themes as long as they were studied in scientific manners, while senior students were given themes of technology and studied under the direction of supervisors.

In 2018, the international self-directed research was introduced in the program. Not only foreign students but also Japanese students were able to apply if the themes were thought to be international.

In 2015, only one class had the regular SPDs. In 2018, SPDs were set for every class as regular classes. Furthermore, four days in autumn term were specified as the days for the self-directed research. These specific days were called "the self-directed research days." There were no classes in these "days," so students could concentrate on their research and faculty members were able to help the students. Autumn term became as busy as other terms for students and faculty members. The jobs of the coordinators became so hard that the new system "facilitator" was introduced. Facilitators were students elected form senior students to help the coordinators for supporting the younger students. They were assigned by the principal through the recommendation of the coordinators. The facilitators were paid for their work, which includes advising younger students in the self-directed research days and in SPDs, reading the comments submitted by younger students, and printing the posters for the presentations. Their work became very helpful for busy coordinators, but no one could not expect how much their work will contribute to the program in the future.

Some changes in 2020

In 2020, covid-19 spread all over the world. It affected our four-term system as well. The college was closed in spring term, when lectures were given online. Although summer term was normal, our college decided to have regular classes in autumn term and postpone the self-directed activities to winter term. Students could not have enough time for their research in the first three terms, for they had regular classes. International research became difficult because students could no longer go to foreign countries such as Singapore, Mongol or Thailand. This year coordinators used to say to students, "Do what you can do."

Since it seemed to be too dangerous to have the presentation in the gymnastic hall as before, the presentation was planned to be held online. Four classrooms were used as the places of the presentation. Each room was managed by one coordinator as the chairperson with the help of two facilitators. Students made their presentations in the class. Two faculty members were assigned as the audience in the room and other people attended these classes online. Until 2019, students gave one minute presentation (so called "the shotgun presentation,") in the morning, followed by the full presentation in the gymnastic hall in the afternoon. They explained their research to wide audiences in front of their own posters for ninety minutes. But, in the online presentation, each student had only seven minutes to explain his or her research. Coordinators made their great efforts to manage the online presentation, because this was the first time for most of the coordinators. While coordinators were struggling to manage the online meetings with their computers, the facilitators helped them a lot. Facilitators were much better than coordinators at using computers. When the network had some troubles, not the coordinators but the facilitators could cope with the problems.

After the online presentation was over, the coordinators had a meeting with the facilitators. Every time they discussed together, the coordinators could hear useful comments to the activities from the facilitators. This time some facilitators suggested to let them work more in supporting younger students. They said that they knew how to find the themes, how to plan the experiments, how to write the final reports, and so on, much better than coordinators, because they themselves experienced the self-directed research for three years. They also said that, for younger students, it must be easier to talk with senior students than instructors like coordinators.

At the end of the 2020 school year, the schedule of the college in 2021 was determined to be the same with that of 2020. Regular classes will be given in spring, summer and autumn terms. Winter term will be the period for the self-directed research with relatively small number of the classes. Coordinators examined the schedule of 2021. They decided to change the self-directed research days to the "Activities." In the "Days," students do their research in the whole day, but it was difficult to spend the whole day only for the research for younger students. Thus, we changed the "Days" into the "Activities." Each "Activity" consisted of two hours after the regular classes. Instead of discussing about their research with the classmates, they gave presentations on what they were planning to do and what they had done before. Students could have good chances to practice the presentation in these "Activities." Picture 4 shows a scene of Activity.

Picture 4 A student is presenting in a "Activity"

The coordinators also made a big change. They planned to schedule specific hours on every Wednesday. These special classes were called "Facilitating hours," abbreviated FH. FHs are times when younger students talk with the facilitators. Every younger student will have a chance to talk with the facilitators once a month. Picture 5 shows a scene of FH.

Picture 5. Facilitators are talking with younger students

Programs in 2021

We survey the activities in 2021. The school year began in April. Everyone thought that we had much time before the presentation, since it was scheduled in February. Students could have enough time to consider their themes before the summer vacation. Facilitators helped the younger students by talking their own experiences, suggesting themes, or just listening to them.

Before the summer vacation began, students made the short presentations about what they will research in the summer vacation. After the vacation was over, they made the presentations about what they actually did in the summer vacation. In autumn term, students had regular classes. Younger students had chances to talk with the facilitators once a month. After these talks with facilitators are over, they submit the themes before the winter vacation. When the new year began in January, they made the one-minute presentations in their classes. Then they submitted the reports of their research. Coordinators evaluated the reports. The reports are not required to be successful. Unsuccessful researches can be acceptable. The most important thing is that student made the research by himself or by herself and the report proved that there were the evidence of the research. If there was evidence of the experiments or observations, then the report will be accepted even if good results were not obtained.

After the evaluation of the reports was done by the coordinators, we had the presentation for three days in February. We hoped to have the presentation in the gymnastic hall that year, but the spread of covid-19 did not calm down. So, we had to have the presentation by online like the previous year. The decision was made on the last day of January. There were only three weeks to prepare for them. Coordinators became very busy. The online presentation of 2020 was a kind of hybrid sessions. Students made their presentations in the real classrooms. But, in 2021, the presentation was held totally online. Every student must attend online. We practiced and practiced talking in the online meetings by using the "Teams" which is an application of Microsoft Office 365. Picture 6 shows a scene of the online presentation.

Picture 6. A scene of the online presentation

Progress in 2022

The self-directed research program is going on in 2022 in almost the same way as in 2021, but there are several changes. One is that the facilitators began to introduce their own research before they talk with younger students in FHs. This is because it seemed that the actual experiments of the senior students must be useful especially when younger students begin to start the research for the first time. The other change is that the facilitators collected various kinds of problems occurring in the local communities by asking local companies and municipal governments. This information will be useful for younger students to find the themes of the research. These two changes were adopted by the proposals from the new facilitators. The third change is having the free discussion room in the time of FHs. In each FH, students are divided into three groups and each group has forty minutes to talk with the assigned facilitators. Some students were complaining that they had to wait for eighty minutes for their turn. That is why coordinators began to open a room at the time of FHs. This change was proposed by a new coordinator.

Problems remained

While experiencing the self-directed research program, we found some problems in this program. The first one is the problem of evaluation of the research of the students. Until 2019, we sometimes saw suspicious reports in which we could not believe if he or she really made that experiment or observation, since these students could not exhibit any photographs, pictures or notebooks about the data. They said that they had lost the notebooks or they had forgotten to take the pictures. Also, we sometimes noticed that some students were missing in the time of their presentation. These students might have escaped from the gymnastic hall when they were to give their presentation to the audience. So, we changed the rubric in 2020 in order to ban these suspicious duties of the students. According to the new rubric, students must do the following two things. One is to give the evidence of the experiments or observations by showing photographs or detailed diary of experiments or observations. The other one is to give presentation to the audience in the time when they are supposed to do. Students will be given two credits only if both of these things are done. If he submitted the report that proves the evidence, but he did not give the presentation to the audience, then he gets one credit. If he did not submit the report in which he could prove the evidence, then he gets no credits and he cannot proceed to the next grade.

The second problem is the lack of the motivation for research. It is true that many students are enthusiastic about their research. These students find interesting themes by themselves and start to do experiments in the summer vacation. Some of these researches are excellent and get awards from our school or outside of our school. On the other hand, there are some students who are not interested in the program. The lack of interest to the self-directed research can be seen even in the excellent students. We see some students who are excellent in subjects such as mathematics, physics and engineering, but they are not interested in the self-directed research. We guess that one reason for this may be that the self-directed research is not evaluated in the same way as the other subjects. In ordinary subjects such as mathematics and physics, students are evaluated from zero points to one hundred points, while in the self-directed research students are evaluated by failure and passed. Almost all the students get two credits for this program and there is no distinction among them. We are wondering that some students may think this to be unfair. Unfortunately, we cannot say that the efforts for the research are measured fairly and they are evaluated faithfully. It would be very good if we could evaluate the attitude of the students and the results of the research fairly. But this is very difficult to do. The evaluation remains to be a very big problem for us.

The third problem is the heavy burden to the coordinators. The coordinators must spend long hours to manage the FHs and Activities. As for the FHs, coordinators have to arrange the groups for the talks of the facilitators and the younger students. They also have to reserve the rooms and arrange the coordinators who supervise the talks. As for Activities, coordinators have to collect the documents for the presentation from the students. They have to combine them into single files for each class, but some students do not submit their documents before the deadline. This happens always. Some students submit wrong files, some students forget to submit the file and some students do not know the deadline. Furthermore, our school has some students who need special care by various reasons. Some coordinators have to work very long hours in order to take care of these particular students. Some coordinators used to work more than forty extra hours per month.

Unexpected success

Although there are some problems which are not solved in our program, there is a great success we could not expected before. It is the power of the facilitators. When we began to collect the facilitators in 2018, we just

wanted them to do simple and easy jobs to help for the busy coordinators. Until 2020, the jobs of the facilitators were not so important. This is partly because that the coordinators thought that education was their job, not of the facilitators. Things changed at the end of 2020. The facilitators proposed to do more jobs than they were assigned and asked. When the FHs started in 2021, the coordinators were surprised to see how effectively this system worked. Facilitators talked with younger students like their brothers or sisters. Younger students talked with the assigned facilitators pleasantly. The proposal from the facilitators was right. Younger students listened to the words of the facilitators better than those of the coordinators. After seeing this success, we began to think of getting help from the facilitators more than before. We also found that the facilitators themselves learned a lot from helping the younger students. These experiences seemed to advance the abilities of the facilitators themselves. They could learn about cooperation and leadership in the groups through the jobs in this program.

Conclusion

More than seven years have passed since our program started and our school seems to continue this program for a while. It is a good time to ask to ourselves how much our program was successful. Answering to this question is not easy. It is best to remember the reason why we started this program. We began this program because we wanted to change the attitude of the students toward learning from the passive one to the active one. We wanted the students to be more active in learning. That is the reason why we let the students find the themes by themselves in our self-directed research program. Usually, students cannot find the themes very easily. In order to find the themes, they consider what they really want to know, what they are interested in, what they are curious about, deep inside their mind. This may be the first time for most students to think about themselves seriously. Some students cannot decide their themes before the summer vacation. When they talk with the facilitators, the facilitators ask, “What were you interested in when you were a child? What kind of games or toys you played?” Then, younger students consider their own history. Even if students cannot find good themes of their own, these experiences have great meanings for them. We want them to make use of these experiences to their studies of the subjects as well as to their lives. We hope that students will change their attitudes a little in studying subjects in the classes. We want them to stop and think about what they mean, why they are true, or how they are applied, when they learn something new in the classes.

It is not easy to measure how much the attitudes of students have changed. Someone says that the graduates of our college became more active these years, but it seems to be a personal impression, rather than an objective fact. There seems to be no qualitative surveys or data about these changes of students so far. But if the faculty members could notice some changes of the attitudes of the students for learning, then we can say that our self-directed research program has been a great success and it is a very good choice to continue this program. To be honest, the first author does not notice that kind of changes in the attitude of students. It must be better to continue to advance our program for the time being in order to say that our program is a success with confidence.

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Industrial Collaboration in Green Technology to Develop Solution Minded Learners in Final Year Project of Civil Engineering Course

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Abstract

From its early days as the first polytechnic in Singapore, Singapore Polytechnic (SP) has been working closely with the government to train and arm the workforce with the skills needed for the country's economic growth. As the pace of globalisation accelerated in the 80s to 90s, the strategic policy was implemented to strengthen and drive towards becoming an innovation economy. This strategy led to the setting up of research and innovation centres in the local Institutes of Higher Learning (IHL) such as SP.

In SP, the Civil Engineering course is one of the first engineering courses that offers a broad based engineering discipline. The School of Architecture and the Built Environment (ABE) is the first school to offer built environment related courses, including the civil engineering course, before being a coordinator of training for the Building and Construction sector among the five local polytechnics.

As an applied learning institution, ABE Civil Engineering has adopted the CDIO (Conceive, Design, Implement and Operate) approach allowing staff and students to engage in real-life and industry relevant research projects to enable the application of knowledge and the use of CDIO skills to conceptualize, design and develop industry relevant solutions. Industrial engagement enabled students in their final year projects (FYP) to directly contribute to real-life such industry projects, while building their proficiency to be solution-minded learners.

Collaboration with industry partner explores the journey that ABE has taken from concept, design to development of its green masterplan, to its evolution and establishment of focus on green technology research that expose students to such research areas through their (FYP) involvement. Two cohorts of FYP student groups from 2020/21 and 2021/22 have been surveyed via face to face (F2F) interview and peer rating of questionnaires. The feedback from the later FYP cohort showed that the students could apply learning to real-world applications after a better engagement in a teaching team consisting of a coordinating lecturer in close collaboration with co-supervisors and mentors from the industry partner. In addition, they can manage their learning, develop team work, good communication skills and work ethics.

Keywords: *Collaboration, CDIO, industrial project, innovative, green technology, solution- minded learner*

Introduction

Circular Economy has become an economic imperative more than ever, compounded with many pressing factors such as game-changing and world-changing phenomena that have changed the industrial landscape. Among these factors, Industry 4.0 revolution, environmental/resource impact, social and regulatory pressures (Lopes de Sousa Jabbour et al., 2018). There is only so much of resources at human's disposal in the current stage, making a paradigm shift from linear to circular the sustainable way to reconcile with the nature (Michelinia, 2017). This far-reaching trend has resulted in many countries, including Singapore, setting zero-waste masterplan as one of its key priorities (NEA, 2020). This paper explores the green journey that the institution, Singapore Polytechnic, has taken from concept, design to development of its green masterplan to its evolution and establishment of focus on the

development of the civil engineering education with green technology infusion.

School of Architecture and the Built Environment (ABE) was the one of the oldest schools in the institution that at one point offered degree courses in 1965, before the decision to transfer the faculties of architecture and engineering to the University of Singapore in 1968. It was of no coincidence that the ABE as the first school to offer Built Environment related course (Singapore Polytechnic, 2018) was appointed as the sector coordinator for Building and Construction among the local polytechnics (MOE, 2016).

Apart from its extensive lesson-based pedagogy, as an applied learning institution, ABE has been through its practical learning platform allowing staff and students to engage in real-life and industry relevant research projects to enable the application of knowledge and the use of skills to conceptualise, design and develop industry relevant solutions. These efforts have paid off well with its projects winning awards for several years in the Greenwave competitions (Sembcorp, 2015). Imbued with passions to pursue industry relevant solutions for augmenting academic excellence, the ABE school's close collaboration with the Advanced Materials and Technology Centre (AMTC) transformed the research ecosystem in the institution into a powerful twin-engine, which allows both the industry-relevant applied pedagogy and the applied scientific research's calibrated integration for allowing the development of an innovative and curious mind-set in its solution-minded graduates (Singapore Polytechnic, 2015). Such kind of industry-research-infused methodology plays an instrumental role, among other strategic initiatives in achieving its mission of "Life-ready, Work-ready and World-ready".

With ABE and AMTC coming together, working on a calibrated approach, such collaborative platform allows for the systematic way of training of both staff and students through a structured framework that encompasses different work packages designed for supporting the industry. The work packages themes are aggregated from the industry, representing the problem statements that requires innovative solutions to either to increase the productivity or the development of specific capability to uplift the industry. In this way, not only does the industry benefit through the skilled and entrepreneurial workforce, such kind of industry engagement with companies offers them the opportunity to transform their business with solutions designed to increase their competitiveness.

In one of the FYPs, waste to aerogel project for example, the partnership with the waste recycling association has yielded successful training and industry projects (Teo, 2018). To close the waste loop, the cooperation and interwoven working network of the waste producer and waste recycler is critical for the business case to work in the circular economy. As such, identifying the right partner to work with from the proof of concept to proof of value and ultimately an industry pilot scale-up is important. Therefore, through the institution's technology development strategy of a "Seed", "Grow" and "Scale" phase of staging technology development projects, there is always an industrial collaborator involvement. While the seeding phase sees primarily laboratory experimental type of projects, most industrial collaborators will generally be more willing to take part in the "Grow" and "Scale" phase where the project is of a certain level of technology readiness level and the commercial potential is more apparent.

CDIO Approach in Developing Solution Minded Learners

Problem solving skill is the most in demand in the workplace. This is reported in an Economist Intelligence Unit report (2015): Preparing students for the future, sponsored by Google for Education. We believe that solution minded is a mind-set that focus on solutions and is an essential driver of problem solving. Jenkins and Germaine (2018) have shown that solution oriented learning helps students to stay positive. It is important to understand that being focused on solutions does not mean that we are denying the existence of a problem but rather it is by identifying a problem or a challenge that leads our step to move forward to the solution.

To support students to become a solution minded learner, the kind of mental activities that leads to this mind-set thinking has to be made visible in their learning process. CDIO approach is adopted to make this thinking visible.

CDIO emphasizes on an approach to strengthen the learning of the fundamentals and at the same time improves the learning of personal, interpersonal skills and product, process and system building skills through experiential learning set in the context of conceiving-designing-implementing-operating (CDIO) team-based environment (Crawley et al., 2007). An integrated syllabus is also crucial in building a structure so that a student can easily grasp it, also supported by some people who has a significant impact on education (Bruner, 1965; Johnson, 2017; Le Francois, 2006) and those who have more understanding of the learning process (Donaldson, 1978, Ali *et al*., 2018). Learning facilitation can increase problem-solving, develop reasoning process, and facilitate motivation (Le Francois, 2006).

Civil Engineering (CE) course, a 3 years programme in ABE, is a broad based engineering discipline, which focuses on developing students' competencies in solving problems in the society while maintaining positive attitude in learning. In recent years, there is an increasing need for civil engineering diploma graduates who have an open mind-set and interest in involvement in tackling sustainability issues.

To equip students with solution minded thinking skills, various problem solving tools or approaches were contextualized into the CDIO stages. Table 1 outlines tools and approaches integrated into CDIO stages in the CE course 3 years' programme.

Disciplinary subjects are mutually supporting when they make explicit connections among related and

supporting content and learning outcomes. An explicit plan identifies ways in which the integration of CDIO skills and multidisciplinary connections are to be made.

Figure 1 shows a diagram illustrating a Challenge Based Learning (CBL) project/ problem based project spine with some supporting modules in the Diploma in Civil Engineering (DCE) course and finally a final year project with all supporting modules in year 1, 2 and 3. It is worthy to mention that a new elective module of R&D in Urban Sustainability was introduced to the course in 2021 to broaden student's knowledge in R&D and sustainability.

Table 1. Problem Solving Tools or Approaches Contextualized into CDIO

CDIO Stages				CE Course	Problem Solving Tools / Approaches			
					Strategies for Question Generating and CBL	Problem solving tools (e.g. Ishikawa Diagram and Scamper)	Design Thinking	Self-Directed Learning (SDL) Strategies
C	D	I	O					
√		√		Year 1	√		√	√
√	√			Year 2		√	√	√
√	√	√	√	Year 3*				√

** Students in CE course do their FYP and Internship in year 3*

Details of the project spine in DCE course described as follows:

Year 1 - Introduction to Civil Engineering module. A project of making a high rise framework using wooden sticks in line with learning basic structure theory.

Year 2 - Water Technology module. Use of CDIO approach to design HDB rooftop rainwater harvesting system in a mini project. A checklist is provided as guiding questions.

Year 3 - FYP with Industrial support. Use of CDIO approach to develop technical skills to design and construct prototypes, as well as to develop thinking, teamwork, communication, learning management, personal attributes.

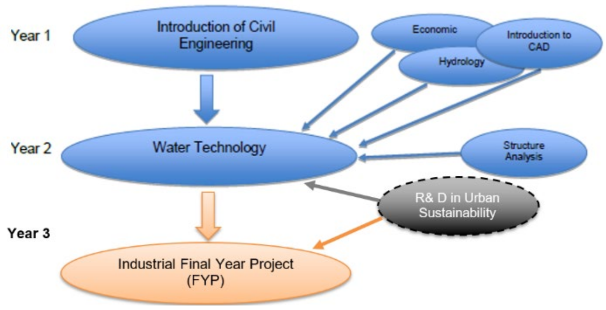


Figure 1. CBL implementation into DCE

During the 2nd Year, a class project assignment that incorporates some 1st year modules such as Introduction to Civil Engineering, Computer Aided Design (CAD), Hydraulics & Hydrology and Economic was developed. In this particular study, a 2nd Year module entitled Water Technology was selected as one of DCE course modules, environmental engineering sub-discipline.

In a nutshell, a class project with the theme of HDB rainwater harvesting was adopted to provide students with a collaborative learning experience working to solve real-world workplace issues, particularly in Singapore context. Results analysis and feedback of this implementation were presented at the Proceedings of the CDIO Asian Regional Meeting (Djati Utomo, 2020).

During the 3rd Year, problem solving tools reinforced with industry supports is adopted to provide students with a collaborative learning experience working to solve real-world workplace issues. The seriousness of the industry in supporting FYP can be seen after two (2) out of five companies gave monetary sponsorship, in addition to in-kind contribution, during the FYP periods. Furthermore, some companies have extended FYP with an interconnecting FYP-internship project in a 2-semester-periods. Through deliberate practices guided by the SDL strategies throughout their 3 years of learning as shown in Figure 2, students were also expected to apply their learning across different contexts in their FYP and to further develop soft skills in the area of self-directed learning, team work, creativity, project management and global mind-set.

As a project focus in academic year (AY) 2021/22, there were five (5) FYP industry sponsored research group with topics ranging from recycling of palm frond for bioplastic making, recycling of plastic waste for road pavement, industrial by-products as feedstock, a 3D printing for DNA extraction and recycling incinerated bottom ash for aerogel making. All FYPs were supervised and coordinated by a DCE staff, co-supervised by some AMTC staff in close collaboration with mentors from different companies to pursue industry relevant solutions. Such engagement in real-life and industry research project settings has provided students the best learning environment leading them to be solution minded leaners. They were also placed in the commercial AMTC laboratory environment.

One example of students' '*solution-mindedness*' that drives the outcomes was their achievement in winning double prizes of Sembcorp Innovation Medal (SWIM) and the 1st runner up in Singapore Junior Water Prize Competition. In addition, most industrial FYPs were promoted for annual event of SP Engineering Show. As a result, many interesting projects were eventually attracting small medium enterprises (SMEs) to sponsor their FYP subsequently.

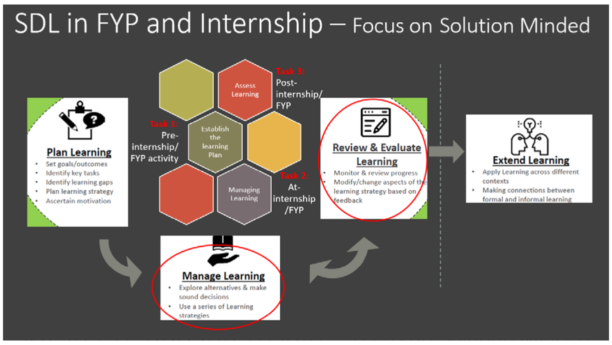


Figure 2. SDL – Focus on Solution Minded Learning

Student Feedback and Analysis

To identify challenges and propose improvements to facilitate the integrated learning experiences, group instructional feedback technique were employed to collect feedback through F2F interviews with the two FYP groups of students in AY2020/21.

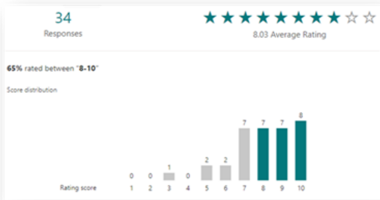
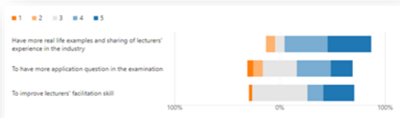
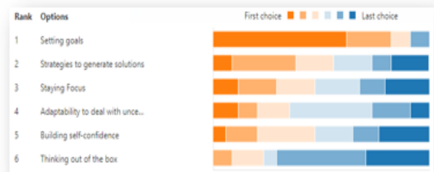
Interview was conducted at the end of their FYP. As students were not explicitly informed that they were on a solution-minded learning journey during their course. They were briefed on the definition of solution minded and to reflect on their learning journey leading them to be a solution minded learner in their 3 years course of study. They were then asked to fill out the following questionnaires and their responses are summarized in Table 2. This preliminary feedbacks were presented at the Proceedings of the 17th International CDIO Conference (Djati Utomo, H. and Soo, N.G.L, 2021)

Peers' ratings of questionnaire formulated based on the input from the F2F interview responses listed in Table 3 and 4 were used to collect data to quantify the identified challenges and improvements. Two groups of FYP students from 2 cohorts consisting 54 students were involved namely AY2020/21 and AY2021/22. There were 34 and 20 FYP students participated in AY2020/21 and AY2021/22 respectively. In these 2 cohorts, a survey was conducted by briefing them on the definition of solution minded and to reflect on their solution-minded learning in their 3 years course of study. They were then asked to complete the survey before their responses being reported in Table 3 below.

Table 2. Group Instructional Feedback from 2 FYP Research Groups in AY2020/21

Interview Questionnaires	Summarized Response
1. What does the lecturer(s) do that help with your learning to be a solution-minded learner?	Lecturers are generally approachable and activities designed are appropriate with deliberate practices leading them to be solution minded learner.
2. What changes/improvements to the course would promote your learning to be a solution-minded learner?	Request for: • more real life examples and sharing of lecturers' experiences in the industry. • more application question in examination • to improve lecturers' facilitation skill
3. What do you do that facilitates your learning to be a solution-minded learner?	Many Students have exhibited self-directed learners' dispositions. However, not able to articulate well specific problem solving tools or strategies.
4. What might you do to improve your learning to be a solution-minded learner?	
5. What is the hardest thing to learn in the journey of a solution-minded learner?	Following key words are identified as the hardest : • Setting goals • Adaptability to deal with uncertainties • Strategies to generate solutions • Staying Focus • Thinking out of the box • Building self-confidence

Table 3. Group Instructional Feedback from 34 FYP students in AY2020/21 cohort

	Questionnaire	Results
1	Generally, lecturers are approachable and learning activities designed are appropriate to lead me to solution-minded.	(Rating are indicated by number of stars where maximum of 10 stars represent lecturers are approachable and learning activities are well designed. More than 65% has rated between 8-10 stars. 
2	Rate the following changes/improvements that would promote your learning to be a solution-minded learner. • Have more real life examples and sharing of lecturers' experience in the industry • To have more application question in the examination • To improve lecturers' facilitation skill	(Rating scale : 1-Disagree 2- Slightly disagree 3-Neutral 4-Slightly Agree 5-Agree) 82% wanted to hear more real life examples from lecturers 53% agree that by having more application question would help  44% agree that an improvement in facilitation skills would help
3	Rate the following dispositions/skillsets that will facilitate/ improve your learning to be solution-minded. • Strategies for Question Generating • Problem Solving Skills (e.g. SCAMPER, Cause & Effect diagram) • Self-directed learning strategies (e.g. 1) setting goals, 2) manage and monitoring learning 3) Review & evaluate learning)	(Rating scale : 1-Disagree 2- Slightly disagree 3-Neutral 4-Slightly Agree 5-Agree) 60% rated 4-5 believed that these dispositions and skillets is important in leading them to be solution minded learners. 
4	Rate the following dispositions/skillsets from the Easiest to the Hardest to achieve. • Setting goals • Strategies to generate solutions • Staying Focus • Adaptability to deal with uncertainties • Staying Focus • Thinking out of the box • Building self-confidence	(Rating scale : 1- Easiest to 5 - Hardest) Majority have rated Adaptability to deal with uncertainity (65%) and  Thinking out of the box (70%) as the most difficult to achieve.

Based on peers' rating collective feedback (Rating scale: 1-Disagree, 2- Slightly disagree, 3-Neutral 4-Slightly Agree, 5-Agree), it can be summarised in Table 4 below:

Table 4. Summary of Peers' Rating Collective Feedback

Points	Discussion
Conceive stage	Majority of the industrial FYP students (i.e. average rating score 4.3 out of 5) can define a given problem/ challenge, identify customer needs, identify the opportunities provided by new technology, identify a set of possible causes to a problem, identify specifications for new products.
Design stage	Majority of the industrial FYP students (i.e. average rating score 4.4 out of 5) can select the most appropriate design, apply appropriate design techniques and tools, evaluate and refine technical design and also develop project plan.
Thinking Stage	Majority of the industrial FYP students (i.e. average rating score 4.4 out of 5) can generate novel ideas, generate different types of ideas, possess better analytical skills, make better inferences and monitor their thoughts.
Linkages	They are still able to develop some connections with other modules (i.e. average rating score 3.77 out of 5.00), apply knowledge to other modules (i.e. average rating score 3.82 out of 5.00), and apply learning to the real-world applications (i.e. average rating score 4.27 out of 5.00).

Due to the nature of the projects is merely considered R&D project with a latest development in the material technology, they might face a quite challenging task since they could hardly made connection with all the civil engineering modules during their previous 2.5 years study. However, the students acknowledged that they could apply learning to real-world applications, as confirmed with an average rating score 4.27 out of 5.00.

In addition, the surveys showed that they could manage their learning, develop team work and good communication skills, active learning and develop good work ethics with the average rating score 4.5 out of 5.0. A better teacher's facilitation skills are shown when students were engaged during multiple discussions with supervisor, co-supervisor and mentor from industry. It was confirmed with an average rating score 4.5 out of 5.0.

To answer some issues as shown from AY2020/21 cohort feedbacks in Table 2, 3 and 4, i.e., the need of more real life examples, improvement of lecturers' facilitation skill, and more application questions, a new group of 5 industrial FYPs (20 students) were formed subsequently in AY2021/22. A more detailed questionnaires to reflect more on CDIO skill sets were asked to be filled in, as shown in Table 5. A CDIO curriculum includes learning experiences that lead to the acquisition of personal, interpersonal, and product and system building skills, integrated with the learning of disciplinary content. Disciplinary subjects are mutually supporting when they make explicit connections among related and supporting content and learning outcomes. An explicit plan identifies ways in which the integration of CDIO skills and multidisciplinary connections are to be made.

Feedbacks from Table 2 to 5 showed that students have gained personal, interpersonal and appropriate disciplinary content and skills through the curriculum but lack of the connection to extended learning as seen in their response to the last questionnaire in Table 2. This is quantified by 34 participants' feedback and narrowed down to improve 2 important disposition/ skillsets.

Table 5. CDIO questionnaires to 5 Industrial FYP (consisting 20 students) in AY2021/22

1 = Strongly Disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly Agree

Construct*		This module has helped me to …	1	2	3	4	5
Conceive	1*	Define a given problem.	○	○	○	○	○
	2	Identify customer needs.	○	○	○	○	○
	3	Identify the opportunities provided by new technology.	○	○	○	○	○
	4	Identify a set of possible causes to a problem.	○	○	○	○	○
	5	Identify specifications for new products.	○	○	○	○	○
Design	6	Select the most appropriate design.	○	○	○	○	○
	7	Apply appropriate design techniques and tools.	○	○	○	○	○
	8	Evaluate and refine technical design.	○	○	○	○	○
	9	Develop project plan.	○	○	○	○	○
Personal attribute	10	Be persistent when solving problems.	○	○	○	○	○
	11	Persevere in face with obstacles.	○	○	○	○	○
	12	Take up new challenges.	○	○	○	○	○
Thinking	13	Generate novel ideas.	○	○	○	○	○
	14	Generate different types of ideas.	○	○	○	○	○
	15	Possess better analytical skills.	○	○	○	○	○
	16	Make better inferences.	○	○	○	○	○
	17	Monitor my thoughts.	○	○	○	○	○
Managing Learning	18	Learn independently.	○	○	○	○	○
	19	Plan ahead.	○	○	○	○	○
	20	Prioritise my learning activities.	○	○	○	○	○
	21	Handle tight deadlines.	○	○	○	○	○
	22	Find ways to overcome obstacles in learning.	○	○	○	○	○
	23	Make proper planning before embarking on practical.	○	○	○	○	○
	24	Conduct information search.	○	○	○	○	○
Teamwork	25	Identify my strength(s) as a team member.	○	○	○	○	○
	26	Contribute to team goals effectively.	○	○	○	○	○
	27	Resolve group differences.	○	○	○	○	○
Communication	28	Better understand the opinions of team members.	○	○	○	○	○
	29	Communicate effectively in my content area.	○	○	○	○	○
	30	Write in a more organised manner.	○	○	○	○	○
	31	Organise my presentation to suit different audience.	○	○	○	○	○
Linkages	32	Make connections with other modules.	○	○	○	○	○
	33	Apply knowledge to other modules.	○	○	○	○	○
	34	Apply learning to real-world applications.	○	○	○	○	○
Active Learning	35	Be actively engaged in classes.	○	○	○	○	○
	36	Participate in class activities/discussions.	○	○	○	○	○
Ethics	37	Make sound judgements according to the rules of professional conduct.	○	○	○	○	○
	38	Act in a manner consistent with the expectation of the society.	○	○	○	○	○
Interest	39	Explain the impact of engineering on the environment.	○	○	○	○	○
	40	Enjoy my classes.	○	○	○	○	○
	41	Maintain a keen interest in engineering.	○	○	○	○	○
	42	Feel inspired to discover new knowledge in my area of study.	○	○	○	○	○

The situation can be improved after they have given more industrial projects with good facilitation skills from a team of supervisor- co-supervisor- mentor. The feedback in Table 4 showed a better engagement and discussion with students could make them more active in executing the FYP. At this stage, feedbacks from industry are not available but the numbers of industrial projects have been increasing in subsequent years.

R&D in Urban Sustainability

To bridge the gap between industrial FYP and conventional modules, an elective module called R&D in Urban Sustainability was introduced to DCE course in

AY2021 as shown in Figure 1. The module aims to introduce students the basic research design principles, various data collection and analysis methods commonly used in science and engineering, and to equip students the knowledge of innovative and sustainable building materials and latest civil engineering (CE) technologies as well as giving them opportunities to practice thinking out of the box. The module reinforces their solution-minded journey and to prepare them for the final year project and working in R&D related companies or lab testing companies. It also develops students' competency in thinking skills, problem solving skills and interpersonal skills like teamwork and communications.

This module is conducted through a combination of lectures, tutorials and practical. Lab testing skills of advanced materials in civil engineering will be covered in the module. Students are expected to participate in workshops, seminars and technical conferences as part of the module requirements. Guest research scientists/ lecturers may be invited to present talks on the latest development in civil engineering. Students will be introduced to a wide range of literatures and case studies will be discussed in the module. Students will form teams and work together to define learning goals as well as negotiate within team members to set project timelines. Lecturer shall play the role as an advisor to guide students in managing and monitoring their learning progress.

Conclusion

An integrated curriculum in a CDIO approach has allowed staffs and students to engage in real-life and industry relevant research projects to enable the application of knowledge and the use of CDIO skills to conceptualize, design and develop industry relevant solutions. Such engagement in real-life and industry research project settings enabled students in their final year projects (FYP) to directly contribute to real-life such industry projects, while building their proficiency to become solution-minded learners who are both innovative and have a curious mind-set.

This integrated learning process can be further realized with staff in close collaboration with the industry to pursue industry relevant solutions. This integrated learning experience (CDIO Standard 7) can foster the learning of disciplinary knowledge simultaneously with solution-minded learning. This was clearly seen in the later five (5) FYP groups in AY2021/22 cohort when the student groups were working on industrial research projects. A good engagement could be well facilitated by a team consisting of teaching staff in close collaboration with co-supervisors and mentors from the industry partner. A bridging module of R&D in Urban Sustainability might be important to be developed to uplift students' knowledge and skills.

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THE FEASIBILITY STUDY OF DEVELOPING BLENDED LEARNING IN VOCATIONAL TRAINING

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Abstract

The COVID-19 pandemic has been sweeping the globe since 2019. All of teachers and students are facing the challenge of changing the mode of learning from face to face to online. Practical classes are arranged to face to face mode, but lecture and tutorial are remained to online mode. Moreover, the traditional face to face exam is also changed to online open book mode. A new blended learning evolved rapidly since 2019. In this study, it aims to investigate the feasibility of blended learning in vocational training. Students' academic performances were analysed via Wilcoxon Rank Sum Test. The results showed in Medical Microbiology, the final mark was significantly different (*p*<0.05) between AY1819 and AY2122, while the practical test mark of Safety and Laboratory Practice was also was significantly different (*p*<0.05) between AY1819 and AY2122. There many factors affect the blended learning outcome, such as the learning differences between students, quality of students, policy of institute, and support from high management level. This is a preliminary study; further investigation is need. All in all, blended learning can be carried on in vocational training, but practical session must be in face to face mode.

Keywords: *blended learning, vocational training, online learning, face to face, F2F*

Introduction

A growing number of students are now opting for online classes. They find the traditional classroom modality restrictive, inflexible, and impractical (Paul & Jefferson, 2019). Unluckily, the COVID-19 pandemic has been sweeping the globe since 2019. All teachers and students are facing the challenge of changing the mode of learning from face to face (F2F) to online mode.

US Department of Education (USDOE) (2009) found that online students preformed "modestly better on average" compared to their traditional, F2F counterparts in a meta-analysis (Helms, 2014). In addition, USDOE (2009) also reported that the differences in implementation of online courses did not affect learning outcomes. However, some studies reported that there was no significantly difference between F2F and online teaching (Beardern, Robinson and Deis, 2002; Jedlicka *et al.*, 2002; Larson and Sung, 2019). There are many reasons affect the research results, such as, the nature of subjects (practical or academic subjects), the quality of students and teachers, and policy of the organization. This implied that there is no absolute answer whether online learning is better than F2F class.

In Hong Kong, Education Bureau, Hong Kong SAR has promoted Vocational and Professional Education and Training (VPET), while its history can be traced back to the first Junior Technical School in the early 1930s (Education Bureau HKSAR, 2020). From the review report, HKSAR Government set up a Task Force on Promotion of Vocational Education in June 2014. It aims to map out a strategy to promote and raise the public awareness of vocational education and recognition of its value. The Vocational Training Council (VTC) was established in 1982, Hong Kong Institute of Vocational Education (IVE) is the member of VTC group. IVE provides Higher Diploma to students. There are nine disciplines, one of them is Health And Life Sciences (formerly named as Applied Science). It included two main aspects, they are Health Programme and Science programme respectively. It aims to equip students with practical skills and academic knowledge, in order to replenish the vacancies in job market after their graduation. In science related subjects, there are many laboratory classes in order to increase student's competence. However, due to COVID-19, some of the laboratory classes were changed to online demonstration, while the others could remain F2F, which depended on the pandemic situation. On the other hand, lecture and tutorial remained to online mode. This created a new blended learning mode in vocational training, which is a challenge to IVE.

In this study, to evaluate the feasibility of blended learning mode in vocational training, the student academic performances from Higher Diploma in Biomedical Sciences are analysed in academic years with all F2F mode and blended learning mode.

Methods

Students from Higher Diploma in Biomedical Sciences in IVE, Shatin campus, their academic performances were collected. Academic year (AY) 2018/2019 and AY2020/2021 of students' academic performance were chosen, including practical test marks and final marks. Students who were absent from the practical tests and examination were withdrawn in the analysis. The modules chosen were Medical Microbiology and Safety and Laboratory Practice. The above modules contained a practical test which counted for continuous assessment. Each module was conducted in one semester only. Medical Microbiology was in summer semester while Safety and Laboratory Practice was in spring semester and both were in the same academic year. Blended learning was started from AY 2019/2020, on the other hand, the AY before 2019/2020, all items were in F2F mode. AY1819 (All F2F, including examination) and AY2021 (Lecture and tutorial were in online mode, while practical session and examination were in F2F mode.

Statistically analysis was performed according to McDonald (2019), which was called Wilcoxon Rank Sum Test (Mann Whitney U Test). The Wilcoxon Rank Sum Test is used due to the outliers in the data while also due to the lack of normality in the data (McDonald, 2019). The data from were test whether they are statistically significant. The p-value chosen was 0.05.

Results and Discussion

Table 1 Medical Microbiology final mark of in AY2018/2019 and AY2021/2022. (Full mark was 100)

	Final Mark in AY2018/2019 (All F2F)	Final Mark in AY2021/2022 (Blended Learning)
Sample Size	76	70
Minimum	16.0	35.0
1st Quartile:	39.8	61.3
Median:	51.0	71.5
3rd Quartile	70.0	82.8
Maximum	90.0	93.0
Mean	53.5	71.0
Standard Deviation	17.4	14.1

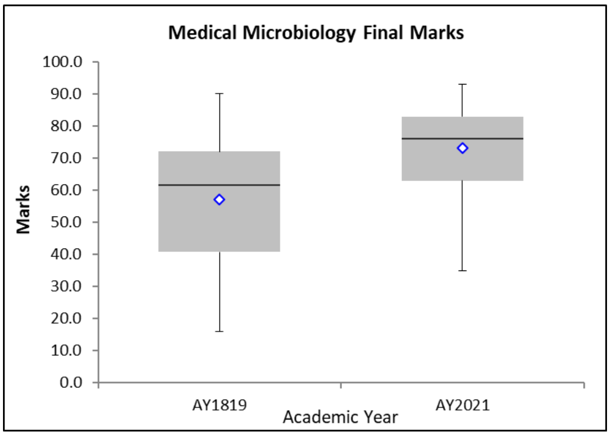

Figure 1 Boxplot of Medical Microbiology final mark in AY2018/2019 (All F2F) and AY2021/2022 (Blended learning)

The first comparison was the final mark of Medical Microbiology in AY2018/2019 and AY2020/2021. The results were summarized in Table 1 and Figure 1. By the Wilcoxon Rank Sum Test, the calculated p-value is 0.0006, which was smaller than 0.05, therefore the distributions of final mark for F2F and blended learning were significantly different.

Table 2 Medical Microbiology practical test mark in AY2018/2019 and AY2021/2022 (Full mark was 30)

	Practical Test Mark in AY2018/2019 (All F2F)	Practical Test Mark in AY2021/2022 (Blended Learning)
Sample Size	76	70
Minimum	8.0	7.0
1st Quartile:	16.0	16.3
Median:	19.0	20.0
3rd Quartile	22.0	23.0
Maximum	29.0	29.0
Mean	18.7	19.5
Standard Deviation	4.9	5.1

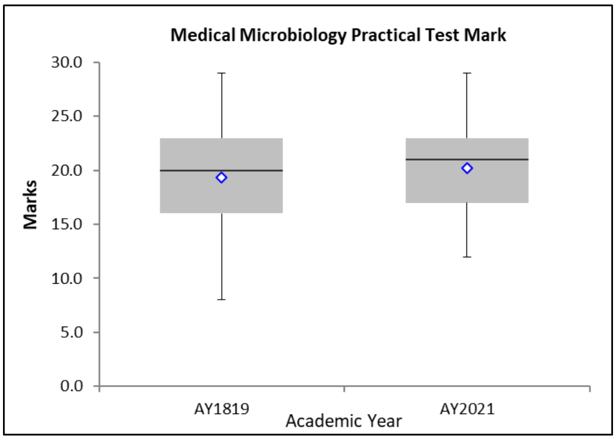

Figure 2 Boxplot of Medical Microbiology practical test mark in AY2018/2019 (All F2F) and AY2020/2021 (Blended learning)

The second comparison was the practical test mark of Medical Microbiology in AY2018/2019 and AY2020/2021. The results were summarized in Table 2 and Figure 2. By the Wilcoxon Rank Sum Test, the calculated p-value is 0.1348, which was larger than 0.05, therefore the distributions of practical test mark for F2F and blended learning were not significantly different.

Table 3 Safety and Laboratory Practice final mark of in AY2018/2019 and AY2021/2022. (Full mark was 100)

	Final Mark in AY2018/2019 (All F2F)	Final Mark in AY2021/2022 (Blended Learning)
Sample Size	90	77
Minimum	14.0	10.0
1st Quartile:	60.0	57.0
Median:	67.0	65.0
3rd Quartile	72.8	70.0
Maximum	85.0	83.0
Mean	65.6	62.5
Standard Deviation	12.8	13.5

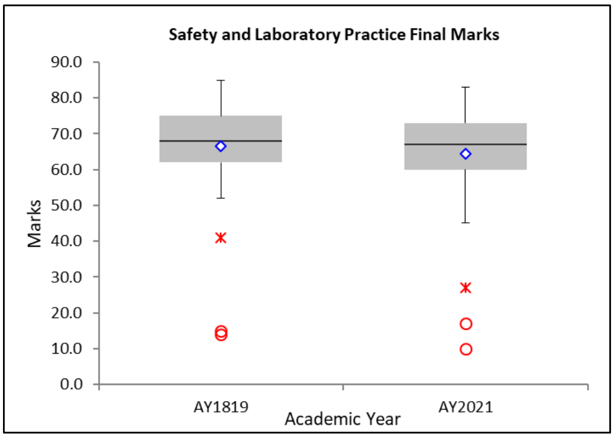

Figure 3 Boxplot of Safety and Laboratory Practice final mark in AY2018/2019 (All F2F) and AY2021/2022 (Blended learning)

The third comparison was the final mark of Safety and Laboratory Practice in AY2018/2019 and AY2020/2021. The results were summarized in Table 3 and Figure 3. By the Wilcoxon Rank Sum Test, the calculated p-value is 0.06, which was larger than 0.05, therefore the distributions of final marks for F2F and blended learning were not significantly different.

Table 4 Safety and Laboratory Practice practical test mark of in AY2018/2019 and AY2021/2022. (Full mark was 100)

	Final Mark in AY2018/2019 (All F2F)	Final Mark in AY2021/2022 (Blended Learning)
Sample Size	83	77
Minimum	45.8	25.9
1st Quartile:	77.4	60.0
Median:	84.1	75.4
3rd Quartile	89.4	87.3
Maximum	98.0	97.9
Mean	81.1	72.7
Standard Deviation	13.3	17.8

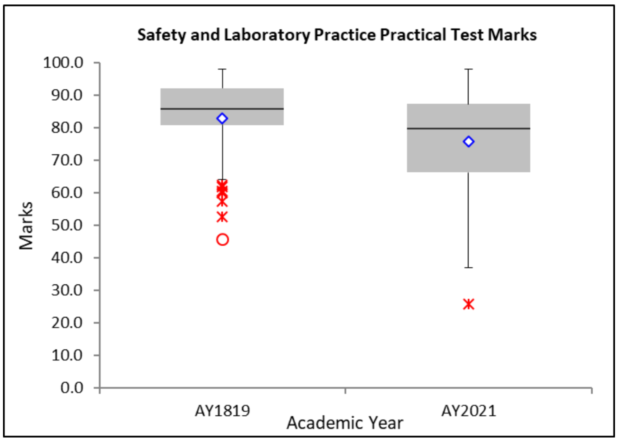

Figure 4 Boxplot of Safety and Laboratory Practice practical mark in AY2018/2019 (All F2F) and AY2021/2022 (Blended learning)

The last comparison was the practical test mark of Safety and Laboratory Practice in AY2018/2019 and AY2020/2021. The results were summarized in Table 4 and Figure 4. By the Wilcoxon Rank Sum Test, the calculated p-value is 0.001, which was smaller than 0.05, therefore the distributions of practical test marks for F2F and blended learning were significantly different.

For both modules, in AY1819, lecture, tutorial and laboratory sessions were in F2F mode , however after AY1819, COVID-19 pandemic was started. The data from AY1920 was skipped because of policy of IVE. The laboratory sessions were called off during AY1920. In order to compare fairly for practical marks, AY1819 and AY2021 were chosen. In AY2021, lecture and tutorial were in online mode, while practical sessions were in F2F mode. Lastly, the final examination was also performed in online open book mode.

For the calculation of final marks, it included continuous assessment (CA) and end of assessment (EA). CA mostly are assignment, laboratory report or exercise, practical test. EA are examination, for medical microbiology, it is written examination, while it is 50 MCQs examination for Safety and Laboratory Practice. Both modules have practical test, which count for CA marks. For both modules, practical tests were in F2F mode, while examination were in online mode, which was an open book examination. Examination paper or MCQs was given and students had to finish and upload to Moodle within a time period.

For Medical microbiology, the difference between final marks in AY1819 and AY2021 were statistically significant, while it was opposite for practical marks. From Table 1, the minimum, 1st quartile, median, 3rd quartile marks were gradually increased in AY2021 compared with AY1819. It is possible that the open book examination is easier than F2F written examination, because students can discuss with each other via WhatsApp, WeChat or Signal. They can also search the answers in the internet. It was not surprising that the students' answers were similar or even as same as each other. Of course, it was also related to the type of question. For example, if the question was critical thinking, it was difficult to copy. However, if the question was straight forward, like 'How did you test whether it is *E.coli* or not ?', it is easier for students to find and copy the answer directly. Al-Qdah, and Ababneh (2017) compared the student's performance in online and paper exams. Surprisingly, the mean and standard deviation statistical results were found to be similar between both paper-based and online exams in the MCQ, True or False, and numerical type of questions; while the essay questions result indicated that the students preferred to answer on paper rather than type on the computer screen. Since there are many variables in online examination, it is difficult to give a conclusion in our study, because of the limitations. But there is no doubt that online examination should be easier than F2F written examination. Their final mark cannot reflect their true academic performance. And further investigation should be performed. On the other hand, there was no significant finding in practical test mark. It is crystal clear that practical classes were performed in F2F, students could learn and practice for their practical test. Therefore, their performances in AY2021 practical test remained as similar as in AY1819.

For Safety and Laboratory Practice final marks, results were shown in Table 3 and Figure 3. There was no significant difference in final marks between AY1819 and AY2021, which was different from medical microbiology final marks. This is because Safety and Laboratory Practice is diploma level, while medical microbiology is higher diploma level, student can handle lower level module easily rather than higher level. Furthermore, the EA assessment for Safety and Laboratory Practice was 50 MCQs, compared with essay type questions in Medical Microbiology. Therefore, it is not surprised that there was no significant difference in Safety and Laboratory Practice final marks. On the other hand, for practical test marks, there was significantly difference between AY1819 and AY2021. From Table 4, all marks were slightly decreased. In addition, the standard deviation remarkably increased in AY2021 compared with AY1819. This is a opposite situation compare with Medical Microbiology. Although Safety and Laboratory Practice is lower level module, the practical skill level is more demanded. The practical test in Safety and Laboratory Practice included four parts, they were weighing item by electronic balance, calibrating pH meter and measuring pH value of sample, performing titration and choosing the right indicator, and lastly, calculating the concentration of chemicals by using the data in titration. Apart from practical skill, it is necessary for student to understand the content of lecture, in order to choose the right indicator and calculate the concentration of chemicals. Although students could come back to campus to have practical class, they must also understand the lecture content. Almendingen, *et al* (2021) investigated the outcomes of online course during COVID19 lockdown. It was reported that the most pressing concerns among students were a lack of social

interaction, housing situations that were unfit for home office purposes, including insufficient data bandwidth, and an overall sense of reduced motivation and effort. This might influence the students' understanding. In addition, students might not be able to ask teacher since they could not go back to campus unless there were practical classes. Therefore, it is reasonable that the student performance became worse in AY2021 compared with AY2122. Apart from the above reason, students from IVE had great learning differences. The data from Figure 3, 4 and Table 3, 4 showed that there were outliers in the data, and also with a great standard deviation.

After the discussion, this raise the question, which is the topic of this study: Is it feasible to perform blended learning in vocational training? To answer that, it is necessary to understand vocational training. VETFest (2020) stated that Vocational education and training (VET) is a key element of lifelong learning systems, which equip citizens with knowledge, skills and competences required in particular occupations and on the labour market. VET responses to labour market in particular occupation. In other words, students shall equip knowledge and skills after graduation and fulfil the requirement of labour market at once. From this study, student can learn and sharpen their practical skills via F2F mode. To evaluate the outcome of blended learning, apart from student academic performance and practical skills test, it is necessary to hear the feedback from stakeholders. In addition, there are many factors which affect the outcome of blended leaning, such as the quality of students, the motivation of students, quality of teacher, support from high level management and the policy of the institute. In this study, it is difficult to conclude whether it is successful to apply blended learning in vocational training, because of many limitations. With considering more factors mentioned above, the study can become all-round. It is still feasible to carry on blended learning in the future. However, there are three important points. Firstly, the practical lessons shall be performed in F2F mode. Secondly, some F2F lectures shall also be performed in F2F mode. Lastly, to increase the motivation of students, it is essential to increase the interaction between students and teachers via technology, such as video quiz, virtual laboratory and online discussion forum. Important, evaluation shall be done regularly to improve continually.

Conclusions

In conclusion, blended learning is not new, it is forced to develop rapidly in these years because of COVID19 pandemic. In this study, student's academic performances were analysed. In Medical Microbiology, the final mark was significantly different between AY1819 and AY2122, while the practical test mark of Safety and Laboratory Practice was also was significantly different between AY1819 and AY2122 For vocational training, teachers and students have to adapt to this now learning mode, which is blended learning. The interaction between students and teachers and student's motivation are the keys to success of blended learning. More investigations shall be done in order to enhance VPET to fulfil the labour market.

Acknowledgements

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Development of a teaching material package for advanced nondestructive inspection education that combines robotics and IoT utilization and nondestructive inspection

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Abstract

In this study, advanced nondestructive inspection education that combines robotics, the Internet of Things (IoT), artificial intelligence (AI), and nondestructive inspection at the National Institute of Technology (KOSEN) was developed, and educational materials for deployment at all KOSEN classes were packaged. Measures against the deterioration of infrastructures built during periods of high economic growth in Japan are facing considerable challenges in terms of infrastructure maintenance. In particular, for the ongoing reconstruction and renovation of infrastructure buildings, introducing the latest technology to quantitatively evaluate the life expectancy of structures is strongly required.

Hence, educating nondestructive testing (NDT) technicians to inspect objects without destroying them is important. Robots, IoT, and AI are being used in the field of nondestructive inspection of infrastructure and structures. Humans performing nondestructive inspections can be automated and remotized using robots. Therefore, the industry needs advanced nondestructive inspection engineers who understand not only robots and the IoT but also nondestructive inspection.

In this study, KOSEN students were educated in NDT using a unified academic system, and advanced NDT engineers were trained in technical skills in robotics, IoT, and AI. KOSEN researchers who specialized in NDT educated students through lectures, experiments, and seminars on the various methods of NDT. Microsoft Teams, a video conference system, was used to deliver lectures and seminars, which were recorded, saved, and packaged as teaching materials. As KOSEN students have been added to Microsoft Teams, they can be taught nondestructive inspection at any time. For the IoT experiment, new teaching materials were created, and a student experiment for "Introduction to IoT" was conducted.

Students who learned how to use these teaching material packages proposed research themes that contributed to sustainable development goals by utilizing nondestructive inspection technology. The results were presented at an academic conference as a nondestructive inspection of a bivalve using elastic waves.

Keywords: *Nondestructive inspection education, Robotics, IoT, Teaching material, Web conferencing system, KOSEN*

Introduction

Currently, in the field of infrastructure maintenance and management in Japan, the problem of aging infrastructure built during a period of rapid economic growth remains. Reliable and efficient inspection techniques are required to quantitatively evaluate the service life of infrastructure buildings during reconstruction and renovation. In this context, educating nondestructive inspection engineers who "inspect things without destroying them" is important. There are qualifications that certify the technical level of engineers engaged in nondestructive testing (NDT) services (The Japanese Society for Nondestructive Inspection). However, these qualifications guarantee the manual skills of field workers and rely on skilled technicians.

Robots, the Internet of Things (IoT), and artificial intelligence (AI) are being used in the field of nondestructive inspection of infrastructure and structures. Humans performing nondestructive inspections can be automated and remotized using robots. Therefore, the industry needs advanced nondestructive inspection engineers who understand not only robots and the IoT but also nondestructive inspection. The problem with current education at the National Institute of Technology (KOSEN) is that it educates KOSEN students on how to utilize robots, IoT, and AI but does not adequately educate them on how to utilize NDT. The reason for this is that various nondestructive inspection methods are based on

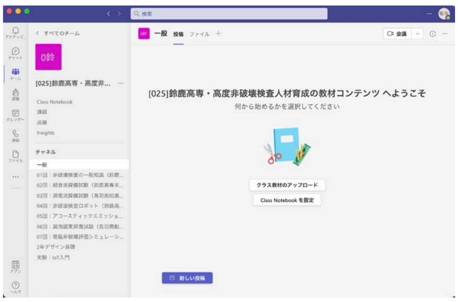
physical phenomena and are applied in many fields (mechanical, electrical, electronic, construction, and civil engineering), which have not been systematized as a discipline. In this study, advanced nondestructive inspection education that combines robotics, IoT, AI, and nondestructive inspection at KOSEN is developed, and educational materials for deployment at all KOSEN classes are packaged.

Creation of Teaching Material Package for Advanced Nondestructive Inspection

Specializing in NDT, we educate KOSEN students through lectures, experiments, and seminars on different methods of NDT. Microsoft Teams, a video conference system, was used to deliver lectures and seminars, which were recorded, saved, and packaged as teaching materials. As KOSEN students have been added to Microsoft Teams, they can be taught nondestructive inspection at any time. For the IoT experiment, new teaching materials were created.

Figure 1 shows the teaching material package for advanced nondestructive inspection. The content created for this study is shown below.

(1) General knowledge of NDT (Lecture by Professor Suetsugu, 53 minutes)
(2) Ultrasonic testing (Lecture by Suetsugu, 59 minutes)
(3) Eddy current testing (Lecture by Yoshioka, 22 minutes)
(4) Nondestructive inspection robot and AI utilization (Lecture by Hashimoto, 17 minutes)
(5) Fundamentals of magnetic materials (Lecture by Hashimoto, 34 minutes)
(6) Acoustic emission (Seminar by Corporate Researchers, 22 minutes)
(7) Flux leakage flaw testing (Lecture by Yoshioka, 10 minutes)
(8) Electromagnetic nondestructive numerical simulation (Lecture by Itaya, 24 minutes)
(9) Introduction to IoT 1 (Teaching material created by Inuzuka)
(10) Introduction to IoT 2 (Teaching material created by Inuzuka)



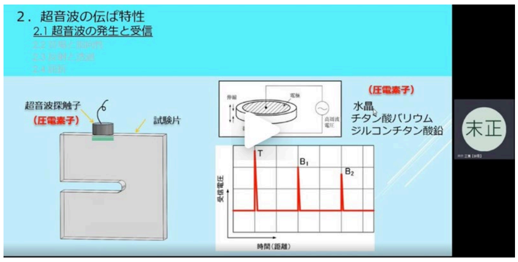


Figure 1. Teaching material package for advanced nondestructive inspection.

They comprise lectures and seminars from general knowledge of NDT to the specialized fields of various nondestructive researchers. In addition, they comprise lectures on robotics and AI utilization and introductory experiments on the IoT.

Advanced Nondestructive Inspection Education for KOSEN Students

Students were recruited for the second-year subject "Design Basics" at KOSEN, Suzuka College. Two second-year mechanical engineering students studied these material packages. Six students from our laboratory studied the lecture on nondestructive inspection. Students submitted daily reports on all lectures and experiments. Figure 2 shows a daily report to confirm students' knowledge of nondestructive inspection. This shows that students understand the importance of NDT and current problems.

Figure 3 shows a seminar on NDT for acoustic emissions. The seminar explained the basic principles of NDT using acoustic emissions and elastic waves. In addition, the lecture introduced the latest research on the NDT of concrete structures using elastic waves by company researchers. The students asked the company researchers about the differences between NDT using acoustic emissions and elastic waves.

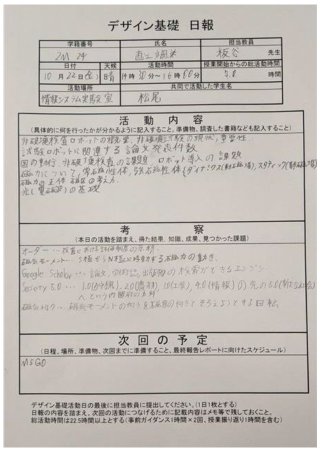


Figure 2. Student's daily report on nondestructive inspection.

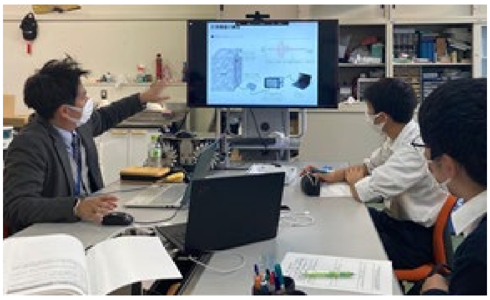


Figure 3. Seminars on NDT for acoustic emissions.

Next, a student experiment for "Introduction to IoT" was conducted. An IoT starter kit called M5GO (M5Stack) was used. M5GO is an improved version of M5STACK with various sensor modules. A GROVE connector is provided to connect the sensor to the main unit. It is designed to be developed in a web browser-based environment. Arduino IDE was used as the development environment for M5GO.

Figure 4 shows the liquid crystal display (LCD) screen of the M5GO, which can be programmed with the Arduino IDE to display text and graphics on the LCD screen. The following exercises were created:

(1) Display text on the LCD screen
Display "Hello" in seven different sizes so that they do not overlap. The text display starts at the leftmost position on the screen.

(2) Display diagram on the LCD screen
Create a sketch in which the shape to be drawn changes depending on the switch to be pressed. Initially, a circle is drawn at random, then a circle is drawn when button A is pressed, a triangle when button B is pressed, and a rectangle when button C is pressed.

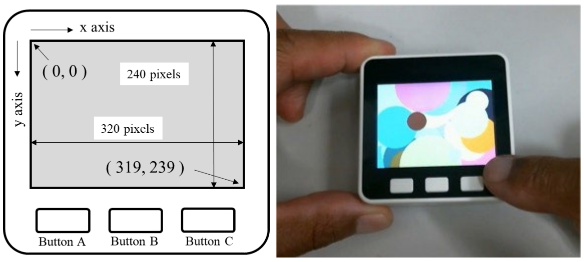


Figure 4 shows the LCD screen of the M5GO.

Next, the operations of the angle, motion, and weather sensors were checked using sample programs. Experiments were conducted to connect M5GO to Wi-Fi and Bluetooth.

Figure 5 shows an experiment using Wi-Fi to graph sensor data in the cloud. Temperature, humidity, and barometric pressure data acquired by weather sensors were displayed in Ambient's cloud via Wi-Fi. Temperature data are transmitted as d1, humidity as d2, and air pressure as d3. In relation to nondestructive inspection, this technology transmits and receives defect data obtained by sensors from remote locations.

Figure 5. Using Wi-Fi to graph sensor data in the cloud (temperature, humidity, and barometric pressure data).

Student's Proposal of New Applications for Nondestructive Inspection

Students who learned how to use these teaching material packages proposed research themes that contributed to sustainable development goals by utilizing nondestructive inspection technology. Their research theme is a noninvasive method of monitoring bivalve habitats in sandy muddy areas for conserving tidal flats.

Figure 6 shows the proposed nondestructive inspection of bivalves using elastic waves. The nondestructive inspection method using elastic waves generates elastic waves in the object and measures changes in the propagation state caused by defects with an acoustic emission sensor. Conventionally, the method has been used in industrial applications for the NDT of concrete structures and bearings. The students considered that in tidal flat organisms, if there were factors affecting elastic wave propagation, their condition could be evaluated noninvasively. The results

were presented at an academic conference as a nondestructive inspection of a bivalve using elastic waves. The proposal for this study was presented at a conference as a nondestructive inspection of bivalves using elastic waves.

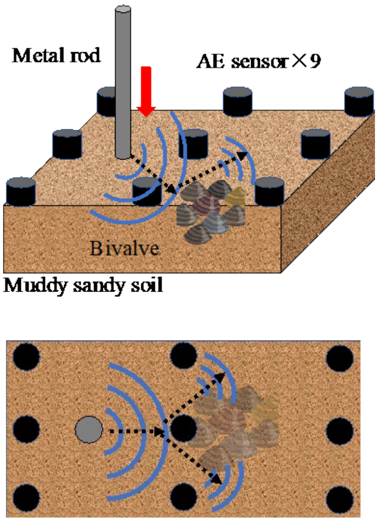


Figure 6. Proposed nondestructive inspection of bivalves using elastic waves.

Results and Discussion

Certain educational effects were obtained for nondestructive inspection and IoT education. However, only a lecture was conducted on the use of robots. Therefore, developing teaching materials for robot experiments is necessary.

Conclusions

We have developed a package of educational materials for advanced nondestructive inspection education combined with robotics and IoT utilization. This package of educational materials is now being extended to other KOSEN students. In the future, we plan to add content to the fields of civil engineering and architecture.

Acknowledgements

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GLOBAL HUMAN RESOURCE DEVELOPMENT IN KOSEN -PERSPECTIVES FROM EFL TEACHING

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Abstract

For the past few decades, it has been widely believed that the expansion of economic globalization increases the need for "global human resources" which enable companies to survive the stiff competition in global markets. Therefore, it now seems critical for Kosen to train "global engineers" in school in order to provide the companies that are expanding overseas with well-trained human resources. Focusing on these recent issues, this study examines the manner and extent to which "global" discourses are influenced and contextualized by social, economic, commercial, and political matters in Japan. It further explores the implications of the findings for teaching Kosen students in EFL classrooms.

Keywords: *Global Human Resources, Education Policy, World Englishes*

Introduction

It has been a long time since the idea that "Using English as a lingua franca is essential for those who will be active in the future, given the globalization of society and the economy.", became actively pervasive in various fields like education, the business world, and the national education policy. This paper aims to examine the discourse surrounding this globalization and, based on a series of arguments, to make recommendations on what can be done in English classes in Kosen.

Background

First, let us discuss the supply and demand of global human resources. The demand for English-language education and human resource development in Japan from business circles and companies has increased in influence with economic globalization. The declining birthrate, aging society, and shrinking population have limited the expectations from the domestic market, and developing and maintaining external markets will require Japan to survive the intensifying international competition. In this sense, the globalization of the economy and industry is a serious challenge not only for the business community but also for the nation.

In a survey compiled by the Ministry of Internal Affairs and Communications in its "Policy Assessment Report on the Promotion of Global Human Resource Development" (2016), approximately 70% of companies indicated that they lack the human resources necessary for overseas operations. There is now a serious mismatch between supply and demand between the education provided as global human resource development and the companies that require those global human resources. To specifically explore the needs of companies, this evaluation report conducted a "Corporate Attitude Survey on the Availability of Global Human Resources," which summarizes the results of 980 of the 4,932 companies with overseas operations, who are the primary entities making use of global human resources, regarding the status of availability of global human resources and their demands. The results of the survey also include requests from companies to higher education institutions for the development of "global human resources," the contents of which are not limited to study abroad and language skills, but include "promotion of study abroad," "expansion of classes related to cross-cultural understanding," "expansion of interactive classes such as debate," "expansion of English classes," and "internationalization of the university through acceptance of international students and faculty members"

The trend toward globalization is no exception for technical colleges. Many companies in the manufacturing industry have overseas offices and factories, and there is a high possibility that graduates of technical colleges will be stationed at one of these locations in the future. Terasawa (2016) concludes that the number of people who use English at work is much smaller than usually thought, with the exception of technical specialists, who use English relatively more frequently. Furthermore, in such cases, while the work at the head office in Japan is usually divided among different departments, overseas offices are often operated by a small number of people, who perform a wide variety of work in general. In such cases, the report points out that there are inevitably more opportunities to use English and other local languages.

In recent years, the term "global engineer" has emerged in the context of the internationalization of

technical colleges. The study tour to Australia conducted by the school is also titled "Study Tour to Become a Global Engineer. The Ministry of Internal Affairs and Communications policy evaluation report mentioned earlier defines global human resources as "people who can play an active role in a variety of fields, based on a deep understanding of Japanese identity and culture, and who have acquired rich language and communication skills, independence, positivity, and a spirit of cross-cultural understanding ” . Based on this definition, "global engineers “could be described as such internationally-minded individuals who can play an active role in the field of manufacturing.

What kind of skills, including language skills, are required for the development of such global human resources? First, the basic premise assumes that most of the English used in such a global environment will be communication between non-native speakers. The English spoken there is likely to be World Englishes or ELF (English as Lingua Franca) rather than the Standard English that native speakers use. In World Englishes, English is not modeled after standard English or native English speakers, and English as a communication tool is the most respected.

On the other hand, language skills for overseas assignments are not limited to English; local languages are also necessary. Kubota's (2015) survey of local staff and expatriates of Japanese companies in Thailand, China, and Korea and Miyamoto and Fujita's (2017) survey of Japanese companies in Vietnam both indicated that the language used in the workplace is unexpectedly more often Japanese or the local language than English, depending on the type of work. In this regard, Kubota (2015) noted that a customer service-related technical employee felt that the closer one is to the site where the machines are actually being used, the more the local language becomes necessary.

Methods

To understand the attitudes of technical college students toward global human resource development, the author conducted a questionnaire survey of 43 students (41 male, 2 female) in one class of 4th-year students whom the author taught at Kosen.

Results and Discussion

All respondents answered positively to Question 1, "English is a lingua franca," with 38 respondents saying “Agree” and 5 respondents saying “Somewhat Agree”. The perception of English as Lingua Franca seems to be widespread among students. Also, it is interesting to note that although the responses to, Question 2: "I would like to interact with people from other countries (English speakers) in English. “, and Question 3, "I would like to interact with people from other countries (non-English speaking people) in English.” were slightly more positive in English-speaking countries, the overall trend in terms of the composition of responses and averages was similar. Combined with the answers to Question 1, it can be inferred that English is a means of communication not only with people from the so-called English-speaking countries of the inner circle, but also with people from other parts of the world. Further, answers to Question 5, "I want to be able to speak English in order to get a job, go on to higher education, or work in the future ", and Question 6: "I want to be able to speak English for pleasure, such as hobbies and interests.” which ask about their motivation for learning English, also show a similar trend, although the practical motivation is slightly higher. This may be due to the fact that students today have more opportunities to experience the benefits of proficiency in English for reasons other than study, as they become more familiar with overseas exchanges and information through the Internet and other means. For Question 4 "I wish I could speak languages other than English. “, a relatively large number of students responded with "Agree" (19) and "Somewhat Agree" (15), indicating their willingness to learn a language other than English. When asked specifically which language they would like to learn, a variety of languages were mentioned, including Russian, Korean, Spanish, Italian, German, Chinese, French, and Portuguese, with Chinese (6 respondents), Russian (7 respondents), and German (8 respondents) being particularly popular. Question 7, "I want to work as a global talent in the future." had the most divided responses, with almost half the respondents saying “Agree" (13 respondents), "Somewhat Agree" (9 respondents), " Somewhat Disagree" (16 respondents), and "Disagree" (5 respondents). Finally, to the free-response question of what besides obtaining TOEIC and other certifications was important in English study, almost all who responded cited speaking as an important factor.

While there are individual differences in the degree to which students are willing to work actively as global human resources, the trend is that they are not biased toward English-speaking countries and are positive about interacting with speakers of other languages through English and other languages and that they want to learn English to enrich both their lives and practically use English. This may suggest that the image of global human resources demanded by countries and companies and the ideal image they aspire to may not be so far apart.

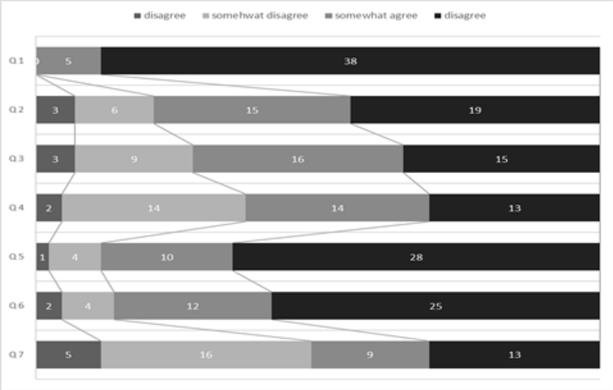

Figure 1: Distribution of Responses

Conclusions and Future Prospect

Summarizing the discussion of what a global human resource is, it is clear that it is quite different from the simple image of a working person who is just fluent in English. In practice, a solid expertise is a prerequisite. In addition, a high level of communication skills, flexibility and tolerance for different cultures, and various other complex abilities are required. The English actually used by these global human resources is closer to World Englishes or ELF than to Standard English, given that it includes a large amount of communication among non-native speakers. In addition, language skills alone are not sufficient to work locally in the first place. Kubota (2015), in her survey, interviewed a variety of employees and found the comment "language is no more than a tool" to be representative. In other words, the most important thing in a job is specialized knowledge and skills. In addition, it is important to be able to interact with people from different cultures without prejudice and be able to properly communicate one's intentions, and English is only a means to that end.

In light of these factors, the field of education has yet to catch up with the demand. For example, in addition to traditional English classes, the author believes that it is necessary to provide students with opportunities to discuss the background of why English is necessary and what kind of English skills they would like to build in the classroom. Although still in the exploratory stage, the author has begun to discuss and report on issues such as English as an official language and misconceptions related to English education for upper graders. Although these efforts have only just begun, it would be beneficial to analyze class reports and student interviews for suggestions for the future as soon as a comprehensive set of data is collected after a certain period of time.

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CONDITIONS FOR A GOOD PROJECT TO PROMOTE THE GROWTH OF KOSEN AS AN ECOSYSTEM ~CASE STUDY OF CYBER SECURITY HUMAN RESOURCE DEVELOPMENT PROJECT~

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Abstract

KOSEN, which has specialized in early-stage engineering education and supported Japan's contribution to industry, is required to further grow and deepen its business in order to respond to the intensifying global situation. KOSEN has launched the COMPASS business in order to continue to grow and make further contributions in five fields (AI, robotics, IoT, semiconductors, and cyber security) that are directly linked to industry and the world. We are responsible for the growth and deepening of the cyber security field and have launched a project to strengthen our faculty and staff in order to develop strong students, which has now been in place for three years. In this project, we also collaborated with internal and external experts to successfully develop strong faculty and staff and, by extension, strong students. KOSEN, which specializes in practical education, has found a good match with cyber security, which is based on practical technology.

As KOSEN is now re-launching itself as a more advanced ecosystem that requires further sustainable development, the significance of the human resources that support the project is significant. Are our projects projects that make the most of human resources? To answer this question, we conducted a survey of faculty members participating in projects in the cyber security field. Is the environment conducive to sufficient performance? Can you walk with your colleagues? Can you enjoy life? In response to these questions, for many faculty and staff who are involved, the sense of fulfillment was higher when the number of years of involvement was longer. We hope that free activities will create a sense of happiness and further spiral up as an eco-system.

Keywords: *Ecosystem, KOSEN, Good project, Cyber security, KOSEN Security Educational Community, Highly Advanced Cybersecurity for KOSEN, Motivation*

Introduction

KOSEN, which has specialized in early engineering education and supported Japan's contribution to industry, is now required to grow and deepen its business in order to be able to respond to the intensifying global situation. In order to achieve further growth and evolution, KOSEN has launched the COMPASS business and continues to grow and make further contributions in five fields (AI, robotics, IoT, semiconductors, and cyber security) that are directly linked to the industry and the world. With KOSEN's potential, a framework is now in motion to continue producing strong engineers.

The predecessor of the cyber security field in the COMPASS project (KOSEN, 2022) as of 2022 is called the Cyber Security Human Resource Development Project (KOSEN Security Educational Community: K-SEC), the first phase of which was from 2016 to 2018 and

the second phase from 2019 to 2021, and has a history of six years of activities. Going back further to its predecessor project, it originated in 2015 as a project of the Education Reform Promotion Division at the Organization of National Colleges of Technology, "Security Human Resource Development Based on Social Needs".

K-SEC (K-SEC, 2016), which is responsible for sustainable development in the cybersecurity field, had two goals. The first is "qualitative improvement," which is to develop outstanding cybersecurity professionals who can compete globally. The second is "quantitative expansion," which is to develop human resources who have systematically acquired the necessary security knowledge in their respective fields of specialization. The Cyber security Body Of Knowledge (CyBOK, CyBOK project, 2019) proposed by Awais (2018) et al. emphasizes the importance of the technology field, and KOSEN education, which focuses on learning the latest technology in a practical format, is an excellent match for cyber security. Society demanded KOSEN students with cyber security skills, and through the promotion of K-SEC, faculty members with strong cyber security skills from KOSEN across Japan gathered together to develop and implement educational materials for cyber security personnel development and to expand the education to all over Japan.

In 2019, Highly Advanced Cybersecurity for KOSEN (HACK), a cybersecurity faculty development project, was launched to accelerate the execution of K-SEC's two goals. The project was born from the simple idea that in order to develop strong cybersecurity students, it is necessary to have strong cybersecurity faculty and staff, and that their development will directly lead to the development of strong students (Yonemura, 2021a, Yonemura, 2021b, Yonemura, 2022). As of 2022, HACK, which has been underway for three years, has been a success, and as a result, K-SEC is now on track.

In 2022, K-SEC, which has begun to re-launch as part of the COMPASS project, which requires sustainable development, has the mission to promote KOSEN's growth as a further ecosystem. At this point, we will take a moment to reconsider HACK, which is responsible for K-SEC. Why is HACK successful? What elements do participating faculty and staff have that are necessary for success? The purpose of this study is to examine the keys necessary for the sustainable development that is expected to continue in perpetuity.

Considering KOSEN's organizational structure, the scale of the project can be said to reflect the thoughts and efforts of individuals, and the conditions for a good project include the following (Laura, 2022, Alesia, 2022).

(1) The environment must be conducive to adequate performance.
(2) The technical field is necessary to support the next society.
(3) To be able to experience growth together with colleagues.
(4) To be able to feel that life is fun.

Forty-seven KOSEN participating faculty members from across the country were surveyed to determine if HACK met these criteria. Many faculty members were interested in cybersecurity and eager to grow. Faculty and staff with more years of participation had a higher sense of well-being, felt that their own abilities to support their teams had improved, and had a higher quality of life/work balance. It can be said that the project provided a sense of well-being for participating faculty and staff.

HACK is a training project for acquiring skills in the field of cyber security, which is essential for further development of the world, and was a good match with the motivation of the participating faculty and staff. In the project to promote KOSEN's future growth, the key points are the technology fields that will create a new era and the development of these fields. This perspective will provide an overview of the HACK project and the knowledge that will accelerate KOSEN's unique growth.

Highly Advanced Cybersecurity for KOSEN (HACK)

In 2019, a new project, Highly Advanced Cybersecurity for KOSEN (HACK), was launched to accelerate K-SEC. The project is based on a simple idea: "When KOSEN faculty is stronger, students are stronger." Figure 1 shows the scheme of the role that the implementation of HACK plays in K-SEC. Nationwide, 51 KOSENs produce approximately 10,000 engineers each year. One of the goals of K-SEC is to ensure that all engineers produced by KOSEN contribute to society with basic security knowledge and skills (quantitative expansion of "plus security" engineers). KOSEN has produced engineers in a wide range of fields, and one of the goals of K-SEC is to develop engineers who can work in the ICT field (qualitative improvement of "plus security" engineers). HACK will be responsible for training faculty members with advanced security knowledge and skills, thereby improving the security knowledge and skills of other faculty members and training KOSEN students with top-class security knowledge and skills.

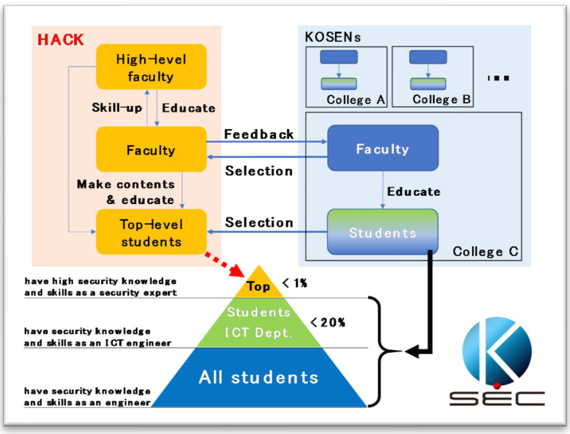

Figure 1. A schematic of the role that the implementation

Date	Topics	Contents
2019/Aug./5	Kick off Seminar	Seminar about offensive security, Catch the Flag (CTF)
2019/Aug./23	Lecture: Web application vulnerability basics	hands on Security company tour and lecture
2019/Sep./18	Remote Lecture 1	Vulnerability of Linux server 1 (SQL injection)
2019/Oct./3	Remote Lecture 2	Vulnerability of Linux server 2 (OS command injection)
2019/Oct/18	Remote Lecture 3	Vulnerability in Windows server 1 (Mimikatz execution trace confirmation)
2019/Nov./12	Remote Lecture 4	Analysis using Wireshark 1 (SQL injection)
2019/Nov./18	Remote Lecture 5	Analysis using Wireshark 2 (C & C Attack)
2019/Dec./2	Remote Lecture 6	Vulnerability in Windows server 2 (Investigation of traces of attack execution)
2019/Dec./11 to 13	Cyber range practice using external contents	Small team defense exercises against attacks on virtual enterprise networks
2020/Jun./10 to 12	Cyber range construction camp	Building a cyber range that can be used during experiments and seminars for KOSEN students
2020/Mar./16 to 17	Making the cyber range teaching materials	Preparation of syllabus, experiment procedure manual and instruction manual for utilizing cyber range

of HACK will play in the ongoing K-SEC project at KOSEN

Date	Topics	Contents
2020/Sep./4	Kick off Seminar	2019 report and overview of the current year
2020/Sep./14	Remote Lecture 1	Virtual Machine Building Exercise
2020/Sep./25	Special lecture by external lecturer	Steps to the front line as a security researcher & Penetration testing practice session hosted by an external organization
2020/Oct./7	Remote Lecture 2	Exercises in Web System Construction
2020/Oct./16	Remote Lecture 3	Exercises on building vulnerable target servers
2020/Oct./23	Remote Lecture 4	Building Virtual Network Environment with Vagrant
2020/Oct./30	Remote Lecture 5	Web Application Firewall (WAF) construction practice
2020/Nov./6	Remote Lecture 6	Vagrantizing a target server
2020/Nov./13	Remote Lecture 7	Practical training on building LAMP stack
2020/Nov./20	Remote Lecture 8	Practical training for building Network intrusion detection (IDS)
2020/Dec./4	Remote Lecture 9	Practical training on building Tripwire (HIDS)
2020/Dec./11	Remote Lecture 10	Practical training in building and operating proxy servers
2020/Dec./18	Remote Lecture 11	Practice of attacks and defenses against Web Application
2020/Dec./26	Remote Lecture 12	Cyber Range Exercise at K-SEC Winter School 2020
2021/Feb./12	Remote Lecture 13	Study Session for Cyber Range Construction Camp
2021/Mar./26 to 28	Remote Lecture 14	Cyber Range Construction Camp

Table 1. 2019 Schedule

Table 2. 2020 Schedule

In FY 2019, the project prepared for the development of education by improving the skills of faculty and developing teaching materials. The learning method for faculty and staff was a top-down approach that involved practical assignments to acquire the knowledge and skills needed to develop a cyber range. The Cyber Range is a virtual training ground in which employee PCs, servers providing web services, and other equipment are placed in a space disconnected from the external network to simulate actual IT services and systems, allowing students to safely learn about cyber attacks on systems and how to defend against them with a strong sense of reality. Faculty and staff attended several CTF (Catch The Flag) training sessions by an external security specialist educational institution with which we have a partnership, as well as remote seminars on topics such as web application vulnerability verification, which were conducted by KOSEN faculty members who are experts in cybersecurity. In December, faculty members attended Cyber Range training held by an external organization. In January, faculty members put into practice their plans to develop their own cyber ranges using the skills they had developed over the year, and completed two cyber ranges as deliverables. Table 1 shows the activities for FY 2019.

In 2020, the second year of the project, faculty members prepared and practiced educational development using the teaching materials they

themselves developed in 2019, the first year of the project. For example, faculty members who were members of the project gave lectures at the K-SEC Winter School for KOSEN students in December 2020. Feedback was obtained from students on the effectiveness of the education, and attempts were made to brush up and improve the security and educational skills of the faculty and staff. Feedback from students is expected to bring innovation not only to security education but also to engineering education, which emphasizes practical education. The course members from the first year, 2019, served as lecturers and gave remote lectures for the new participating faculty and staff. Finally, as in 2019, thedevelopment of teaching materials was conducted in March to further improve skills. 2020 activities are listed in Table 2.

Date	Topics	Contents
2021/Aug./30	Kick off Seminar	2020 report and overview of the current year Special lecture by external lecturer titled “AI and information security”
2021/Sep./13	Remote Meeting 1	Confirmation of annual plans
2021/Oct./1	Remote Meeting 2	Confirmation of themes for teaching materials to be created by each faculty member
2021/Nov./7	Remote Meeting 3	Sharing information on educational materials under development
2021/Nov./26	Classroom Observation 1	Special lecture by external lecturer titled “Cyber Security through classroom lectures and exercises”
2021/Dec./3	Remote Meeting 4	Confirmmation progress of annual plan and sharing information
2021/Dec./13	Classroom Observation 2	Special lecture by external lecturer titled “ Hacking Techniques and Root Privilege Escalation“
2021/Dec./17	Classroom Observation 3	Lecture by KOSEN faculty member titled “DNS cache poisoning“
2022/Jun./14	Remote Meeting 5	Confirmation of contents for summary camp
2022/Mar./24 to 25	Remote Meeting 6	Report on the implementation of the annual plan at the summary camp

Table 3. 2021 Schedule

The two scenarios used in the Winter School were "Breaking into the Teaching System" and "WordPress Vulnerability". At the Cyber Range Construction Camp in March, participating faculty and staff constructed a cyber range to experience DNS cache poisoning as the culmination of six months of training. Through practical exercise lectures using this material, students can deepen their understanding of the Domain Name System (DNS), learn the concept of Kaminsky attacks, and enhance their overall network security skills.

The third year, 2021, was the deployment phase, which consisted mainly of practical activities for lectures using the Cyber Range that had been developed so far. The participating members gave practical lectures at KOSEN, to which they belong, and also served as lecturers at the K-SEC Winter School 2021, where exercises were conducted using the Cyber Range developed so far. The scenarios used in the Winter School were "WordPress Vulnerability" and "DNS Cache Poisoning," which were developed by this project, as in 2020. The basic policy of this year's activities was to further develop teaching materials and prepare for their deployment. Each participating member created new teaching materials, regularly checked their progress, shared information, and improved their skills in the course of modifying the direction of the project. In addition, several lecture tours to KOSEN students by internal and external experts were conducted for reference in the deployment of lectures. Table 3 shows the activities in FY2021.

Through the above activities, we were able to confirm the improvement of the skills of the faculty and staff, as well as those of the students in the lectures given to KOSEN students. The HACK project that has been promoted in this way has achieved a certain level of success.

Examination of the conditions for a good project and results of the questionnaire survey

This chapter examines the extent to which HACK meets the conditions for a project to be appropriate as an ecosystem, and if so, what those conditions are. A questionnaire was sent to 47 faculty members from KOSEN across Japan who participated in the project (first year of participation: 15, second year of participation: 15, third year of participation: 17) to ask them about their thoughts on the HACK project. The survey was conducted on March 18, 2022, and responses were received from 47 participants in about one week. Responses were given on a 5-point scale, with some textual fluctuation depending on the question, but the stages of response were as follows; 5: very strongly agree (100%), 4: very agree (75%), 3: so-so (50%), 2: a little (25%), 1: not at all (0%).

The conditions for good projects discussed in this study were defined by reference to the causal combination linking job satisfaction and commitment (Laura, 2022) and the items discussed in Happiness at Work (Alesia, 2022). In order to further examine whether the conditions were met, 19 questions were set in the questionnaire. The conditions, items, and typical questions are as follows.

Condition (1): The environment must be conducive to adequate performance. *Related items:* Physical working conditions, freedom to choose how to work, assigned responsibilities, diversity of work, sense of accomplishment and autonomy.

Condition (2): The technical field is necessary to support the next society. *Related items:* Awareness of own condition, cognitive well-being.

Condition (3): To be able to experience growth together with colleagues. *Related items:* Colleagues, development and sharing of empathy and sympathy. *Question:* Do you feel connected to the members.

Condition (4): To be able to feel that life is fun. *Related items:* Physical health, mental well-being. *Questions:* The degree to which you are willing to work with your team members to see the same future?

Figure 2 shows the average of all of the response scores to the 19 questions. The vertical axis shows the scores and the horizontal axis shows, from left to right, the first, second, and third years of participation, allowing one to see the overall trend in member responses according to years of participation. The analysis of variance results show a marginally significant in the main effect of years of participation ($F_{(2,44)} = 2.67$, $p = .081$). This means that we can see a trend that members with longer years of participation have stronger feelings about the project, but one result indicates that the project as a whole is a good one, since such a result would not be reached if the project were not a good one.

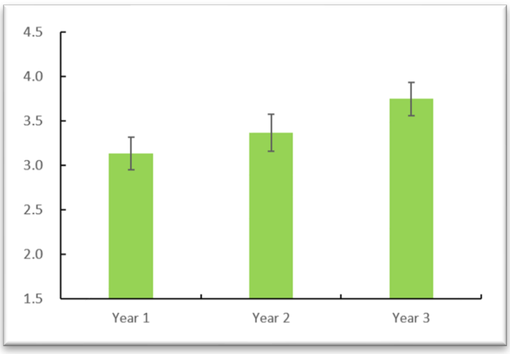

Figure 2. The average of all of the response scores to the 19 questions

We focused on the relationship between the length of participation and the intensity of feelings from various perspectives. The relationship between the length of participation and the strength of feelings suggests that participation in the project itself may have a positive impact on the individual. In turn, this positive influence, together with the positive impact of the project, can serve as a driving force for the sustainable development of the project as an ecosystem, thereby increasing the feasibility of achieving the project's objectives.

Figure 3 shows the response scores for the question regarding condition (3), do you feel connected to your peers as a result of your participation, and the results of the analysis of variance show that the main effect of years of participation is significant ($F_{(2,44)} = 3.59$, $p < .05$). Figure 4 shows the response scores for the question regarding condition (4), "Will you continue to work with the members of this project after the project is completed and disbanded, looking to the same future?" The results of the analysis of variance showed that the main effect of the number of years of participation was significant ($F_{(2,44)} = 4.03$, $p < .05$).

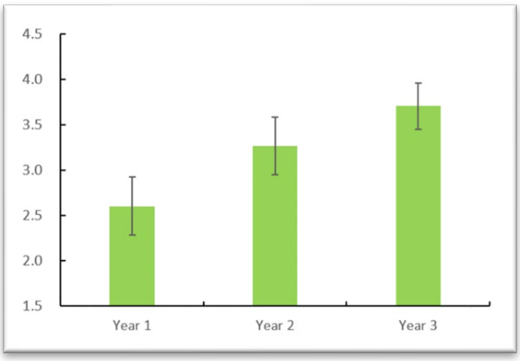

Figure 3. The response scores for the question regarding condition (3), do you feel connected to your peers as a result of your participation

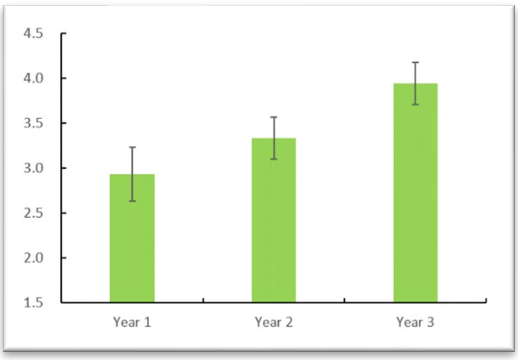

Figure 4. the response scores for the question regarding condition (4), Will you continue to work with the members of this project after the project is completed and disbanded, looking to the same future?

Based on the representative results in each of the above conditions, we examined whether HACK meets the conditions for a good project. HACK is a project that can respond to some degree or more to the desire of participants to improve their skills, as it is a place that can provide more than a certain level of environment for adequate performance. HACK will also support the motivation of the participants on a sustained basis because it is a technical field that will support the next generation of society. Furthermore, as a place where participants can experience growth together with their peers, the project will foster human relationships and create stimulation that will enhance each individual. Finally, this is an excellent project that can contribute to physical health and mental well-being and improve the balance of life and work by providing a place where people can feel that life is enjoyable.

Conclusions

In 2022, K-SEC, which was re-launched as part of the COMPASS project being promoted at KOSEN, which requires sustainable development, has the mission to promote KOSEN's growth as an even higher-performing ecosystem. K-SEC is a mature and successful project that has been in existence for seven years and counting since its predecessor. HACK, which has been responsible for faculty development within K-SEC, is also a successful project. In this study, we reexamine the significance of HACK, which has important implications for the environment surrounding KOSEN and for KOSEN, which needs to deepen and grow as an advanced ecosystem. Why has HACK been successful? What elements do participating faculty and staff have that are necessary for success? The purpose of this study was to examine the keys necessary for sustainable development that is expected to continue in perpetuity in the future.

We will look at the details from the questions and consider the elements that KOSEN faculty and staff possess. Faculty members who had participated in the project for a greater number of years were clearly more interested in cyber security. This is why they joined the project early on, but the most important factor is that the direction of the technology field is an important technology in society that KOSEN faculty and staff can easily become interested in. Faculty members who participated in the project for a greater number of years felt a greater degree of connection with their peers as a result of their participation. Friendly competition with peers is always a powerful motivator. This characteristic was also strongly expressed by KOSEN faculty and staff. Faculty members who had participated in the project for a greater number of years also strongly felt that they would be able to continue working toward the same dreams and pictures with their colleagues after the project was completed. Participation in the project has given them the ability to find joy and pleasure in their lives in the future, and they are now enjoying their lives in no small measure. In general, the survey results can be summarized as follows: all four conditions examined were met, and HACK is a great project that makes the most of the faculty and staff at KOSEN.

From a broad perspective, the key to KOSEN's sustainable development is, needless to say, its faculty and staff. Human resources are human assets. This may be an obvious statement, but our examination of the conditions for a good project this time reaffirmed it in a definite way. KOSEN, which has many wonderful human resources, will surely continue to grow and contribute by producing human resources to support society.

Considering the individual characteristics of KOSEN faculty and staff, projects at KOSEN should be free activities. In reality, however, a climate has already been established at KOSEN in which faculty members can work hard to improve their own skills in the midst of such free activities. Therefore, this fact contributes greatly to the improvement of the quality of happiness of the faculty and staff, the improvement of the life-work balance, and ultimately, the improvement of the quality of happiness of the students. HACK is an excellent project that fulfills these conditions and will greatly contribute to the further growth and deepening of KOSEN in the future. At the same time, it is an excellent project that will bring a sense of well-being to the faculty and staff who support it. Spiral Up as an ecosystem will continue to grow and develop. We can fulfill our duties as faculty members with confidence and conviction.

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LEVERAGING INDUSTRY PARTNERSHIP TO BUILD FUNCTIONAL COMPETENCIES FROM AN INNOVATIVE R&D PROJECT ON DISTRIBUTED LEDGER TECHNOLOGY[1]

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Abstract

Republic Polytechnic (RP) has always taken a unique approach to learning, where we seek to equip lecturers and students with the intellect, and practical skills needed to solve real world problems by engaging in industry projects with tangible requirements. This paper reveals the partnership between RP and R3 LRC Singapore through a synergetic approach to develop a Distributed Ledger Technology (DLT) system to manage food supply chain.

This collaborative project has provided an orthodox platform for RP lecturers and students to engage in industry immersion learning. The aspiration of the collaborative project was to develop a tracking and traceability system that utilizes DLT to address the issue of food authenticity and safety. We have created a public-permissioned blockchain as an information infrastructure system to track and trace livestock from farm to fork. As blockchain is a decentralized ledger used for storing transactions, they could track the order and payment status between companies in the food supply chain by using well-known cryptographic primitives to protect the data.

By distributing transactions over a distributed network of nodes, it can achieve permanent storage of orderly transaction records that are immutable, open, and traceable. By leveraging on smart contracts to implement the terms of an agreement, process owners can trade safely and efficiently without any third-party mediation, thus solving the trust and equity issues in the business world. Coupled with the integration of IoT technology such as GPS sensors to read and write data to the blockchain, the system can increase supply chain management transparency, mitigate counterfeiting and fraud issues, and increase consumer satisfaction.

This project provides our lecturers and students with the necessary tools and skillsets to challenge large-scale as well as highly distributed and complex software development in the near future. The development of our DLT system was carried out over a period of 24 months by lecturers and teams of final year students from the School of Infocomm (SOI), with close guidance and contribution from the expert in R3. The collaboration project has not only provided a focal point for lecturers at RP to keep abreast with the latest developments in Fintech industry, but it also offered our students the opportunity to build up their relevant skillset relating to blockchain technology and application development.

Keywords: *industry project, collaboration, project translation, distributed ledger technology, blockchain technology, Fintech, smart contract, supply chain.*

Introduction

With the incursion of new emerging technologies, the industry work environment has transformed dramatically over the last twenty years. The industry today not only needs a workforce that is equipped with academic knowledge, but also skillsets that comprise of a high level of technical aptitude, interdisciplinary professional competencies, highly flexible, collaborative attitude, and a globally oriented perspective. Enaging in relevant industrial Research & Development (R&D) projects is one of the primary mechanisms adopted by SOI to provide lecturers with capability development, as well as providing our third-year Infocomm students with an opportunity to gain authentic hands-on experience to effectively practise what they have been studying for the past two years. Besides requiring the students to undertake a full scale analysis and development of a working software, the scope of the project has to be defined in collaboration with an industry partner. Therefore, the purposes of an industry project are to:

- divulge lecturers and students to the realities, considerations and challenges while working on software development project within the industry.

[1] This work was supported by the Ministry of Education, Singapore under grant MOE2018-TIF-1-G-033

- provide opportunities for lecturers and students to interact with industry practitioners and obtain feedback on their produced work.
- motivate lecturers and students to deliver outcomes and values that companies can potentially apply and implement within their business environment.

Enaging in industry project is one of the key exposure to the full rigour of industry practice. Therefore, it is crucial for us to learn it through industry collaboration. It is particularly important to not just apply what we know conceptually, but to be able to apply it with good judgement. We should also have the ability to assess what we are doing critically and to be tactful of it.

The key objective of this paper is to discuss the synergetic strategy RP has adopted to develop a DLT project collaboratively with the fintech industry. Before we examine further on our collaborative sourcing, it is worthy for us to describe concisely on blockchain technology and the issue on food safety. The project we have developed is a DLT application to address the issue. Hence, understanding methodically on how DLT works has became the foremost reason for us to work with the chosen industry collaborator.

Background of Food Safety

As the growth of population worldwide, along with rising incomes in developing countries, Elferink and Schierhorn (2016) has indicated that the dietary changes of eating protein and meat are driving up the global demand for food. Uçar et al. (2016) and AVS Lab (2021) have emphasised that food safety is becoming important as it helps to protect consumers from the risk of food borne diseases and illnesses. Food safety also helps to prevent consumers from the risks of health–related conditions such as allergy and even death. Unsafe food containing harmful bacteria, viruses, parasites, or chemical substances causes more than 200 type of diseases, ranging from diarrhoea to cancers. According to the World Health Organisation's (WHO) (2021) report, an estimate of 600 million people has fallen ill from eating contaminated food and approximately 420,000 die every year, resulting in the loss of 33 million disability-adjusted life years (DALYs).

Challenges of Food Safety in Supply Chain

The online article from *It's about Time Urgent Care* (2017) has revealed that the challenges to food safety will continue to emerge in recent time, largely due to the rise in global temperatures from climate change that leads to food contamination, facilitating import and export of perishable food from cross-border trading, as well as new and emerging bacteria, viruses, toxins, and antibiotic resistance present in crops and livestock.

There are several steps to supply food from the farm or fishery to the dining table. We call these steps the food supply chain. Contamination can occur at any point along the chain from production, processing to distribution. Production means growing the plants we harvest or raising the animals we use for food. Most food comes from domesticated animals and plants, and their production occurs on farms or ranches. If the fields are sprayed with contaminated water for irrigation, fruits and vegetables can be contaminated before harvest.

Processing involves different steps for different kinds of foods. For animals, the first step of processing is slaughter. Meat and poultry may then be cut into pieces or ground. They may also be smoked, cooked, or frozen and may be combined with other ingredients to make sausages. During the slaughter process, germs on an animal's hide that came from the intestines can get into the final meat product. Uyttendael *et al.* (2016) revealed that germs can spread to foods when they contaminate surfaces used for food processing, such as a processing line or storage bins.

Distribution means getting food from the farm or processing plant to the consumer or a food service facility like a restaurant, cafeteria, or hospital kitchen. For instance, if refrigerated food is left on a loading dock for long time in warm weather, it could reach temperatures that allow bacteria to grow. Furthermore, fresh produce can be contaminated if it is loaded into a truck that was not cleaned after transporting live animals or animal products.

WHO (2021) estimated that US$110 billion was spent each year in medical expenses and loss in productivity resulting from unsafe food in low- and middle-income countries. Food safety and food security are indistinguishably linked. Unsafe food creates a vicious cycle of disease and malnutrition, particularly affecting children, elderly and the sick. Food borne diseases impede socioeconomic development by straining the nation's health care systems, and harming economies, trade, and tourism. Hence, accessing to safe food is the key to promote good health and sustaining life.

Concept of Blockchain and Distributed Ledger Technologies

DLT is a decentralized database managed by multiple participants, across multiple nodes. Blockchain, on the other hand, is a type of DLT where the transactions between two nodes are recorded with an immutable cryptographic signature. The blockchain technology was first proposed by Nakamoto (2008) to eliminate the need for a trusted third party to authenticate the transactions. The idea is to rely on each node in the network to maintain a ledger for recording transactions. By decentralizing the ledger and building trust among multiple parties, Hazari et al. (2020) indicated that blockchain technology not only reduces the transaction costs but also speeds up the actual transaction process.

Tapscott and Tapscott (2016) described every node in a blockchain has a pair of private and public keys. Each time a transaction is sent over the blockchain, it is signed with the node's private key to ensure authenticity. The

signed transaction is then broadcast over the network where all or some of the nodes must execute a consensus algorithm to evaluate and verify the proposed block to be added. As illustrated in Figure 1, if most of the nodes come to a consensus that the proposed block and its accompanying signature are valid, the new block of transactions will be added into the ledger and the new block will be added to the chain of transactions. If most of the nodes disagrees with the proposed block, it will be rejected and will not be added to the chain. This distributed consensus model is what allows blockchain to operate as a distributed ledger without the need for some central authority to specify which transactions are valid.

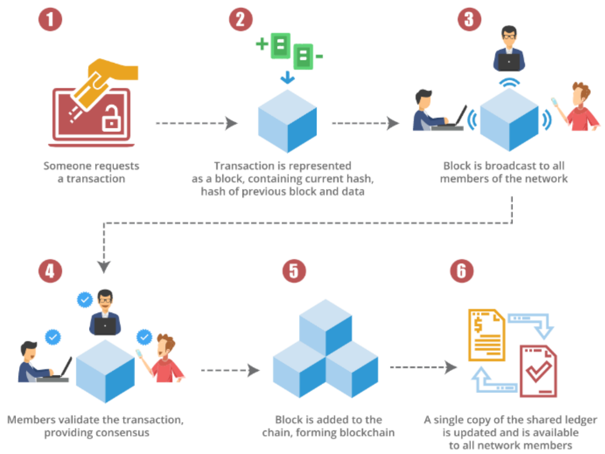

Figure 1: A blockchain is a chain of time-stamped blocks that contain an immutable record of data managed by a cluster of nodes[2]

Currently, many new blockchain platforms have been researched and proposed. Ølnes and Jansen (2018) divided these platforms into permissioned and permissioned-less, which it can be further subdivided into public and private blockchain. The permission aspect refers to the different types of permissions that can be granted to the participants of a blockchain network. The permissions as defined in the table are read, write and commit. “Read” is the ability to read information from the blockchain, “Write” is the ability to conduct transactions, and “Commit” refers to the ability to append data to the blockchain. For instance, in a public permissioned-blockchain, the blockchain is completely open to anyone for downloading and viewing but only all or a subset of authorized parties can write and commit transactions to reach consensus, as indicated in Table 1.

In contrast, a private permissioned blockchain limits the viewing of transactions to only limited users that have been approved by certain authority and only the creator of blockchain network or some entity appointed by an authority can contribute to the consensus of the ledger state. An example of a private permissioned blockchain would be an internal bank ledger shared between the parent company and its subsidiaries. In general, each blockchain implementation has its own merits and significance in terms of privacy and scalability aspects. Hence, which model to use will depends on the type of network, the requirements, and the specific application scenario.

Table 1: Types of blockchain implementation

			Read	Write	Commit
Blockchain Models	Open	Public Permissioned-less	Open to anyone	Anyone	Anyone
		Public permissioned	Open to anyone	Authorized parties	All or subset of authorized parties
	Closed	Private permissioned-less	Restricted to an authorized set of parties	Authorized parties	All or subset of authorized parties
		Private permissioned	Fully private (restricted to limited authorized parties)	Network operator (creator of network)	Network operator (creator of network)

Managing and Improving Food Safety with Distributed Ledger Technology

To overcome these challenges of food safety, we have developed a tracking and traceability system utilizing DLT and Internet-of-Thing (IoT) sensors to streamline the workflow of supply chain management in agri-food industry. In doing so, it mitigates the complex business processes and speeds up the workflow of working through multiple business owners. Moreover, it reduces the paperwork involved to improve productivity while adding security to make food supply chain more robust, especially the necessity of importing and exporting perishable foods from cross-border trading. With blockchain, movement and authenticity of products could be tracked, thereby creating a permanent history of a product from farm to fork. This could potentially reduce time delays, costs associated with contract-making as well as human errors that plague traditional food supply chain today. As illustrated in Figure 2, our DLT system aims to achieve the following goals:

1. To provide transparency to the process flow in a food supply chain. Customers can track and trace food provenance as well as food safety issues, if any.
2. To remove the need for intermediaries, such as administrators and lawyers by promoting direct interactions between two parties. This is to save costs and avoid unnecessary delays.

We adopt a public-permissioned blockchain network in our tracking system where only approved supply chain partners can participate in writing and validating the transactions. The customers can also access the blockchain. However, their access is limited to viewing transactions to check food provenance. They are not allowed to create transactions. To improve the efficiency and scalability of the blockchain network, the tracking system uses notary nodes to conduct consensus to maintain the consistency of the public ledger. We have concurred with Palmisano et al. (2022) that using notary nodes could eliminate high processing overhead and energy consumption that are associated with other

[2] Takyar (2022)

popular consensus methods, such as the Proof-of-Work (PoW) used for cryptocurrency mining.

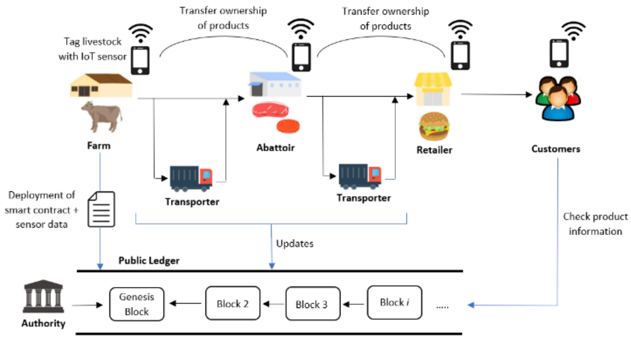

Figure 2: Architecture of blockchain-enabled tracking system

Motivation behind Collaborative Sourcing

RP's curriculum has demonstrated a strong focus in the technological area of fintech. The key motivation behind our collaborative sourcing remains to be competence development. To achieve this, we have collaborated with R3 LRC Singapore (www.r3.com), one of the first companies to deliver the only private, secure, and scalable DLT platform designed for regulated markets. R3 also maintain one of the largest DLT production ecosystems in the world, connecting over 400 institutions from both the private and public sectors. Under the partnership arrangement, RP will make independent contribution to the project delivery in terms of manpower deployment, equipment, facilities, and other technological contributions. On the other hand, R3 has assisted us in undertaking the project with technology sharing, technical advices and guidance relating to our development of CorDapps (Corda Distributed Applications) running on Corda blockchain. The benefits from our collaboration are listed as follows:

Lecturers:

- Improve understanding of the fundamentals of blockchain technology, as well as the involvement in the theoretical and performance studies of consensus mechanism and smart contract.
- Build up skill capabilities by involving in DLT development for food supply chain.

Students:

- Project opportunities allow hands-on industry experience for students about DLT systems. The Industry Immersion Programme (IIP) allows our internship students to develop vital software components for our DLT system.
- Equip students with the latest technology of DLT sytems used in the industry.

Transforming Plans to Reality

Our implementation process is divided into three work phases. Each phase has to be developed sequentially as follows:

Research Work (WP1) – The objective of this work phase is to research existing predictive analytical methods and to study the interoperability of IoT with blockchain smart contracts to streamline the food supply chain operations. As outlined in this proposal, the general framework for tracking the movement and authenticity in food supply chain management has been introduced. Lecturers will continue to work closely with our industry partner to derive functional specifications to enhance the framework. In addition, lecturers will also work collaboratively to develop new predictive analytics tool in AI that could accurately envisage breeding, illness, as well as the menace of infection from food borne diseases.

Development Work (WP2) – This phase is responsible for the technical development and system integration of the Corda framework. Various development tools and software technologies will be used to develop blockchain networks, smart contracts, mobile applications and field-testing of the sensor devices. The project team and our industry partner are to create the necessary software solutions and hardware tools that will be used to collect and generate relevant operational data for eventual analysis.

Evaluation (WP3) – The aim of this phase is to analyse the performance of the DLT system. More specifically, involving in stress tests for the following performance metrics, such as transaction success rate, number of transactions per second, the time it takes transactions to settle and resource consumption, such as CPU, data storage and memory. These performance tests will help the project team to identify performance bottlenecks, define metrics for tuning the system, and assess the scalability of our DLT system.

Throughout each development phase, the lecturers would carve out some portions of the software components for our internship students. For traceability purpose, we have recommended our project team and internship students to manage their project development works using GitHub, which is an Internet provider to host source code repositories for software version control and collaborative project management.

Translation of Project Outcomes into Academic Curriculum

With new technologies thriving at breakneck speed, there is a need to facilitate the translation of knowledge generated from applied technology, solution, and innovation from industry projects into Pre-Employment Training (PET) and Continuous Education and Training (CET) curriculum in RP.

Before the start of our DLT project development, the project leads will need to identify potential modules, new modules or Final Year Projects (FYPs) for possible project translation. A translation plan has also been developed, which includes technical knowledge and

skills acquired from our DLT project. During the project development phase, we have rolled out FYPs in alignment with our project schedule. At this stage, we segregate our DLT project into smaller industry linked FYPs. In the case of cross disciplinary FYPs, it is recommended for the supervisor to leverage the expertise from other schools within RP to address the possible knowledge gap.

When opportunity arises, we would recommend our team members to engage in Industry Attachment Scheme (IAS) with the industry. IAS is meant for staff industry attachment, and it should be arranged in the last two months before the DLT project ends, where it is typically done as an industry validation stage. The aim for this recommendation is to provide lecturers involving in our DLT project with the opportunities to gain valuable experiential learning opportunities in the company that could eventually be translated into authentic learning to enrich our curriculum.

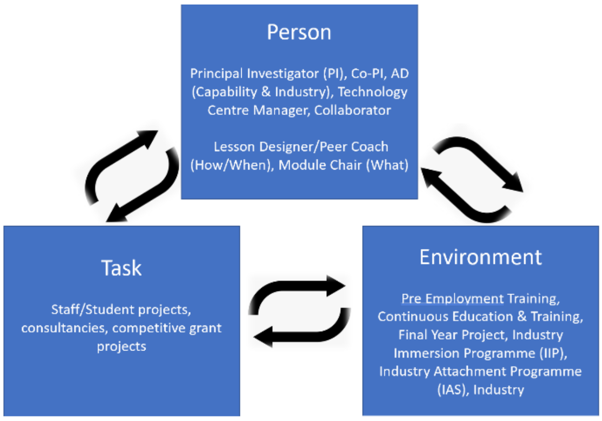

Figure 3: Key elements to translate knowledge from applied technology, solution and innovation into curriculum

After the completion of the DLT project, we will need to work closely with the module team to implement and disseminate translation outcomes to relevant modules. Possible outcomes from the project development could comprises of one or more of the follows:

- Lesson plan
- Lecture notes
- Lab worksheet
- Pre-reading materials
- Problem trigger (for problem-based learning)
- Case studies
- New CET short courses

Lastly, lecturers involved in industry project development or IAS should consider sharing their experience and best practices in regular school meetings, learning retreat or Community of Practices (CoPs).

Results & Discussions

Our developed DLT system can potentially bring many benefits to the process owners and consumers in food supply chain. Consumers are more likely to trust the quality and safety of the food they consume. For abattoirs, retailers and logistics companies, they could benefit from escalated productivity, cost savings and boosted process transparency by eliminating paperwork through digitalisation. Thus, allowing businesses and their customers to trade and transact directly at lower costs. In terms of security, all contract transactions processed by the DLT system are stored in chronological order in the blockchain and distributed across multiple systems. The transaction blocks are linked to each other and secured using well-established cryptography to provide high data integrity. No one can alter the contents of a block as all other nodes on the blockchain will detect this discrepancy and mark such an attempt as invalid. Regulators can also exploit the immutable feature of blockchain as an audit trail to verify compliance and detect food fraud. Compared to other blockchain-based solutions such as Waltonchain and Vechain, our DLT system is cost-effective, interoperable, highly adaptable and sustainable as it does not rely on incentivised mining and it can operate on easily available hardware.

The successful implementation of the Corda blockchain will serve as a reference for other Agri-tech companies to learn and branch out into other agri-food or aquafarming industries to increase the economic productivity in Singapore. It can also serve as a reference to other supply chain DLT applications as well. It is hoped that our DLT system will generate more awareness of food safety by consumers in the supply chain.

The development of our DLT system was carried out over a period of 24 months by lecturers, project engineers and teams of final year students from SOI, with advices and guidance from the fintech expert in R3. Due to the number of limited qualifying lecturers with adequate knowledge in DLT, our project development was divided into several work phases. The collaborative project has inspired us to improve our technical competency and capabilities in fintech. In the process of facilitating the collaborative efforts between our students and industry partner, it has provided us an opportunity to apply relevant project management skills in different stages of the software development lifecycle (SDLC). As for our internship students, our IIP has provided them a good opportunity to comprehend realities and to tackle challenges. It also permits them to interact with industry practitioners and obtain constructive feedback on their produced work.

As collaborators, we haved harnessed on our students' work by incorporating the source code produced by the IIP students into our DLT prototype. This is done after thorough code validation by the members of the DLT project team. With this collaborative approach, not only will our students have the opportunity to engage themselves realistically in the industry project; we are also able to harvest better ideas and innovations from their uniquely qualified minds.

Conclusion

In this paper, we have shown how DLT system for food supply chain can be synergistically developed in a creative, innovative and productive manner. Tapscott et al. (2006 & 2012) indicated that collaboration is presently a profoundly new approach to orchestrating capability to innovate, solving problems and creating better IT products. Combining the principles of collaboration, sharing, integrity, interdependence and openness have provided the blueprint for us to get our industry project accomplished.

In RP, we constantly seek to provide our IIP students with the intellectual and practical skills needed to solve realistic problems by engaging them in genuine industry projects. Immersive experience through industry engagement, and peer learning among teams of students, are two key elements of our pedagogy. We are certain that through the collaborations with our industry partners, our lecturers and internship students will not only enrich ourselves from the learning experience, but can also contribute something significant and relevant to the industry at the same time.

Acknowledgement

It is a great pleasure to acknowledge Mr Benjamin Kimsiah Tan, former solution architect of R3. Ben has been very supportive of our DLT project. Without his cooperation and coaction, the project will not have been in existence. It is a great privilege working with him.

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EDUCATION BASED ON THE REGIONAL ISSUE OF NUCLEAR POWER

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Abstract

Maizuru KOSEN is located in the northern part of Kyoto Prefecture, where, is border with Fukui Prefecture. Fukui prefectre has many nuclear power plants such as Takahama, Oi, Mihama and Tsuruga. In Japan, nuclear power plant has been renovated by the accident at the Fukushima Daiichi Nuclear Power Station in the Great East Japan Earthquake. Nuclear is considered to be an important power generation technology in the future considering the stable supply of energy in Japan. The Maizuru KOSEN is working on education to improve students engineer skills by Problem Based Learning (PBL) on solving the problems of this important nuclear power generation. In this paper, the authors report on how we worked on engineer education conducted through solving problems in liquid sodium research in nuclear research. This course starts with having lecture by a researcher who is conducting nuclear research at a nearby nuclear facility taking advantage of the location of Maizuru KOSEN. The first step of this course is organizing information of the current situation and issues of nuclear power generation and listening to the voices of the people in the field. A researcher explain issues in the nuclear field to students, the student thinks about the solution. Students think about how to solve problems in the field of nuclear research. At present, students are asked to work on project in teams of several people, but it is necessary to consider the optimum number of students to enhance the educational effect. Students come up with various ideas from a young and flexible perspective. The task at this time was to consider a method for removing the oxide film on the surface of the liquid metal generated during an experiment at the Japan Atomic Energy Agency. We ask them to present their ideas, give advice to the extent that they do not hinder the independence of students, complete the design, and actually produce it. Students test the manufactured equipment to see if the results are as predicted by the students themselves. In addition, the researcher themselves give feedback to the students whether or not the device works by using the ideas in the field of research. In conclusion, since it was a new initiative, various opinions were received from the students. The authors will continue to explore the problems and make the content more educational.

Keywords: *nuclear, fast breeder ractor, P.B.L., regional issues, engineer education*

Introduction

The lecture on energy environment in the Maizuru KOSEN aims to improve students' practical skills by having students consider solutions to the problems of nearby nuclear power plants. In particular, issues related to nearby fast breeder reactors are regional issues that are limited to Maizuru KOSEN and Ibaraki KOSEN, even among technical colleges nationwide. An important issue related to fast reactors is related to liquid sodium used as a coolant, and at Maizuru KOSEN, liquid sodium researchers are asked to provide relatively simple but important issues, and students are asked to solve the problem. We aim to improve students' abilities by having them think about it. In 2020, the first year of this initiative, we asked students to come up with solutions to two issues. One is the study of the method of removing the oxide film generated on the surface of the liquid during the experiment of liquid sodium, and the other is the method of cutting the solid sodium as thinly as possible.

Methods

The lecture was conducted according to the following flow. First, we invited a liquid sodium expert from the Japan Atomic Energy Agency to give a lecture on liquid sodium. Unless students have a detailed understanding of liquid sodium, they cannot propose correct problem-solving methods. At the end of the lecture, we asked students to explain the issues that are problematic in the field of research on liquid sodium, and presented the issues to students at the same time. This is a week's worth of lectures. The following week, the students were divided into teams and each team was asked to come up with a solution to the problem. There is team division in the event that becomes a problem when performing PBL. Most social activities are carried out by teams. Forming

a team leads to simulating this activity, and while it seems to have a positive educational effect, there is also the risk that some will not be left to others. In this initiative, we tried to form a team of two to three people so that there would be no non-participation. After the team formation was completed, each team was asked to think about how to remove the oxide film of liquid sodium, which is an issue, and to summarize it in the presentation material. In addition, in order to manage student activities and reduce the information gap, slack, a project management tool, is used, and the activity status of each team can be reported on slack so that members of other teams can see the contents. The authors made it possible. The following week was an opportunity for researchers to give their opinions on the ideas that the students had in mind. While student ideas are free and novel and can surprise us, they can also be too far from reality. Bridging that gap is the reason for setting up a place to present ideas. But be careful not to say too much negative here. Do not deny the student's ideas, but ask only the parts that you have doubts about. By doing this, The authors tried to avoid having a negative impact on students' free thinking and creating a bland similar thing for all teams. Next, The authors asked the students to actually make a jig to remove the oxide film of the liquid metal that they came up with. It took some time to make it, but they devised each one. The problem here was that some students wanted to make it with a 3D printer, and The authors basically admitted that, but in this case The authors couldn't actually test the function using liquid metal. High-temperature liquid metal is difficult to handle, and after thinking about it, it was decided that if oil was floated on water and this oil was removed, it would fulfill the required functions. This test was planned to be conducted with solder, but in reality, most of the tests were conducted with oil floating in water for safety reasons. For ideas with excellent results in this mock test, researchers at the Japan Atomic Energy Agency actually conducted a test to remove the oxide film of liquid sodium in the laboratory, confirmed the effectiveness of the idea, and confirmed the effectiveness of the idea. The performance was fed back to the students.

The next thing the students thought about was how to slice solid sodium into thin slices. The content is more difficult and practical than the first task. Although metallic sodium is solid at room temperature, it is relatively soft and can be easily cut. The feel is like cutting oil clay, which can be easily cut, but it is very difficult to cut it into thin slices. By presenting this slightly difficult task to the students, the authors tried to find out how difficult it was and to give a hint as to whether the educational effect of the difficult task was high. The flow of the lecture is the same as the first task, with experts from the Nuclear Research and Development Organization giving lectures, students devising problem-solving methods, students presenting proposals, manufacturing devised devices, mock tests, etc. The work proceeded in five steps of the actual laboratory test.

Examples of problem-solving proposals proposed by students

Here are some examples of the oxide film removal methods proposed by students in this lecture.

The first team is to pinch and remove the oxide film on the surface, assuming that a comb-shaped jig and a special rectangular container are used. It's an interesting idea, but it seems that there was a leftover oxide film. In addition, it takes some time and effort to manufacture the jig.

Fig. 1 Oxidation film removal method devised by A Team

The method devised by the next team was inspired by the phenomenon that sea waste is collected on a sandy beach.Slopes that look like sandy beaches are prepared at both ends of a container for liquid metal, and an oxide film is applied to this slope. It is to collect. The authors think it's an interesting idea, but it seems that the shape and dimensions of the slope were not enough in the prototype, and it seems that the collected oxide film returned to liquid metal again.

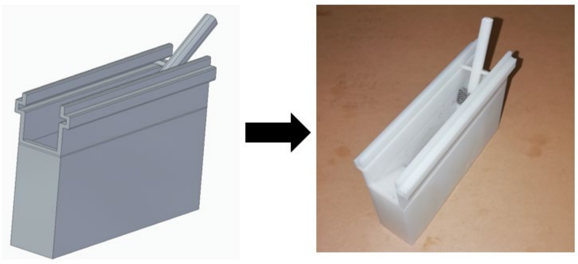

Fig. 2 Oxidation film removal method devised by Team B

The idea devised by the next team is to prepare a lid with a hole, and when the lid is put on the container containing liquid sodium, the oxide film is pushed out from the hole, and at this time, by plugging the hole, only the oxide film is used. It is to selectively remove it. This is also an interesting idea, but it didn't work to plug the holes, and it seemed that the liquid would return to the container when the lid was lifted. In addition, when the oxide film is removed, it does not function unless the height of the liquid surface is above a certain level, which is also a negative point.

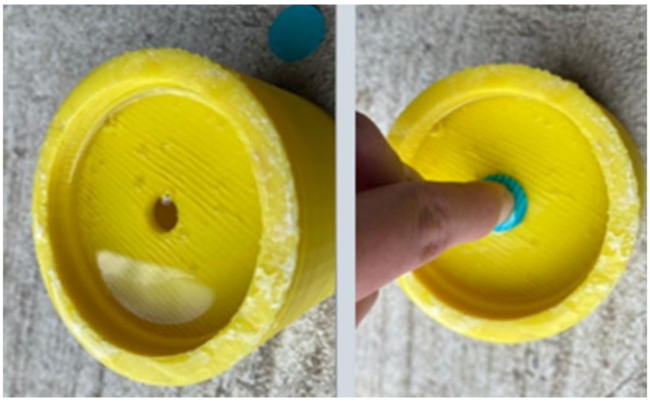

Fig. 3 Oxidation film removal method devised by Team C

The idea devised by Team D was to use the surface tension of liquid metal to push the oxide film out of the container and remove the extruded oxide film at once with something like a knife or spatula. Although this idea is simple, it has received the highest praise from researchers in the field. It seems that maintaining a high liquid level at all times is a little difficult, but it is said that the oxide film can be removed in a shorter time than the current method of removing the oxide film, which is the method of scooping with a net.

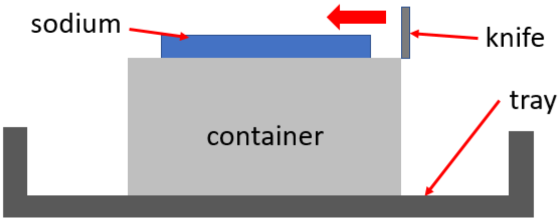

Fig. 4 Oxidation film removal method devised by Team D

This is the solution proposed by the students to the problem of slicing metallic sodium. For these relatively difficult tasks, student ideas seem to be summarized in several patterns. In this case as well, it was either stretched thinly or cut with some ingenuity. When cutting, a guide for slicing is used, but many students devise something like a slicer for cooking. Due to our lack of explanation, many students came up with ideas to grow, but if they came up with ideas on the premise of cutting, it seems that some students would come up with interesting ways to cut. When setting a task, it is important to determine some prerequisites.
The first team proposed the idea of making a mold of the required shape, putting solid sodium in it, and molding it. A thin product was made, but it is difficult to release the mold, which is a problem.

Fig. 5 Thin film molding method devised by Team A

When molding by cutting, many teams devised slicers. Some teams designed their own slicers, while others suggested the slicers they purchased from the beginning because the purchased products had better performance.

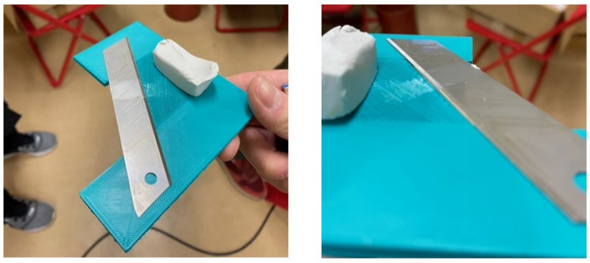

Fig. 6 Thin film molding method devised by Team B

Conclusions

The authors made efforts to improve students' problem-solving ability by having them think about solutions to actual problems in society. Taking advantage of the location of Maizuru KOSEN, we were able to contribute to the solution of regional issues, receive regional cooperation, and receive regional cooperation in an attempt to proceed with regional cooperation on the theme of nuclear power as a regional issue. The authors think this was also meaningful for student education. The authors would like to continue to make better efforts while making improvements.

Acknowledgements

This initiative was carried out with the cooperation of the Japan Atomic Energy Agency. We would like to express our gratitude to Mr. Mori and Ms. Komori for their cooperation.

THE POTENTIAL OF DIGITALISATION FOR COLLABORATIVE QUALITY ENHANCEMENT

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Abstract

Quality in Vocational and Professional Education and Training (VPET), also commonly known as technical education worldwide, is acquired over a long period. Each VPET institution has its own strengths, constraints and priorities for quality enhancement depending on its history, tradition, management style, culture. In addition to the institution itself, different stakeholders contribute to quality enhancement and help ensure that learning programmes are academically and professionally recognised. Hence, the keys to quality enhancement (QE) rest in continuous capability building, in addition to identifying and sharing of good practices.

With rapid technology advancement, various kinds of information and data have been continuously and increasingly converted in a digital format for easy storage, access and sharing. Entering an age of digitalisation, education has been transformed in several ways, bringing a number of benefits and challenges. In VPET, digitalisation encompasses changes ranging from online teaching and learning, to new pedagogies, as well as the digitalisation of existing documentations and work flows. As digitalisation is pervasive, it creates new opportunities for capability building and knowledge exchange, which are the keys for collaborative QE in VPET.

The purpose of this paper is to examine the potential of digitalisation in facilitating different stakeholders during the on-going quality enhancement routines. Through the possibilities offered by collection of data and its smart evaluation and usage, this paper will also shed lights on how institutions may apply digital tools to build competencies and empower different stakeholders to collaboratively exchange good practices.

Key stakeholders to be included in this perspective paper are employers and industries, VPET institutions, students and teaching staff. Instead of engaging in a hierarchical relationship, education institutes may adopt and utilise various embed digitalised technologies to better support these stakeholders in continuously going through a collaborative review, discussion and capability building process. These embed technologies may include big data analytics, automation, digital interfaces and connectivity.

The conclusions will include insights and good practices to applying digitalisation approaches to facilitate collegial continuous improvement. With this as a backdrop, the paper will stimulate thought and discussion about collaborative quality enhancement at international levels.

Keywords: *vocational and professional education and training, quality enhancement, QE, digitalisation, collaboration, best practices*

Introduction

Quality Enhancement in VPET

Instead of focusing on quality assurance (QA), quality enhancement (QE) has become a new focus of VPET institutions to bring about continue improvement in the effectiveness of learning and teaching (Elassy, 2015; Kwok and Yuen, 2021). QE raises standard to a higher degree whereby VPET takes the responsibilities for purposely develop and enact a more holistic internal quality assurance system to drive continuous improvement. Such structural enhancement relies on the contribution and support from diversified stakeholders (Gvaramadze, 2008).

As a result of organisational maturity and a continuum of QA, QE gives greater space to academics and is integrated in daily learning and teaching while promising more than just assurance (Gvaramadze, 2008; Filippakou and Tapper, 2008). It is regarded as a formative treatment process that focuses on the present and future outcomes (Biggs, 2001; Brink, 2010; Fillippakou and Tapper, 2008; Lomas, 2004; Gibbs, 2011), With a transparent quality culture promoting engagement of different stakeholders, QE enables VPET institutions to systematically and continuously improve

the quality of education programmes including but not limited to programme design, implementation and delivery.

The Role of External and Internal Stakeholders in QE

Diversity of stakeholders is engaged to ensure continuous QE of VPET programmes, thereby cultivating work-ready graduates who can excel in the relevant industry and professionalism. Though the composition of these skeholders may be slightly difference among different VPET institutions, they generally include both internal and external stakeholders are take part in different stages of programme development, operation, management, review and enhancement. Apart from involving in a specific learning programme, some of these stakholders, such as employers, professional bodies and associations, not least graduates, also help ease students' route to professional and international recognitions.

Instead of engaging in a bureaucratic relationship or working in silo, these stakeholders must collaborate and go through an ongoing review, discussion and capability building process to ensure effective QE. Therefore, it is important for VPET isntitutions to understand who the stakeholders are and how they could best contribute to QE, which utimately add value to themselves (as an individual, a team or organisation), relevant industries and the society as a whole.

Digitalisation in VPET

Accelerated by the COVID-19 pandemic, digitalisation has been infiltrating every facet of our lives. Education sector including VPET is no exception. An increasing number of educational tools are being employed to facilitate teaching and learning in VPET institutions. Online learning management systems, for example, are adopted by many VEPT institutions in the creation of dynamic courses / modules with teaching and learning materials in additional to the assessment tasks due. The online systems are able to facilitate real-time synchronous discussion among teachers and students and enable them to work collaboratively in forums and database, not least bringing efficiency and innovation into classroom.

Taking one of the notable VPET institutions in Hong Kong, the Vocational Training Council (VTC), as an example, workplace learning and assessment (WLA) is conducted via a tailor-made electronic platform. Using performance tracking tools available on the online learning management platforms, students' academic performance is being recorded digitally and could be tracked efficiently. Other higher education institutions are also adopting similar online platforms, web conference system as well as various software products and digital tools to facilitate digital learning (Perrin and Wang, 2021).

Theoretical Framework

Any person or group that can influence or be affected by an organisational action, strategy or project is referred to be a stakeholder (Freeman, 2010; GPPAC, 2015). According to the stakeholder theory, an organisation must consider and integrate needs of all its stakeholders so as to sustainably create values to a common goal (Jones, Harrison and Felps, 2018). In higher education, including the context of VPET, stakeholder theory has been widely applied to investigate a variety of subject matters, including the role of stakeholders in institutional governance, research agenda and assessment (Amaral and Magalhaes, 2002; Jongbloed, Enders and Salerno, 2008; McDowell and Sambell, 1999). In the recent decade, studies applying the stakeholder theory in to understand the roles of different relationships in facilitating quality assurance has proliferated (Beerkens and Udam, 2017; Leisyte and Westerheijden, 2014; Lyytinen et al., 2017; Tetteh, Amoako-Gyampah, and Twumasi, 2014).

In VPET, different stakeholders may influence the process and outcomes of QE. These stakeholders, including frontline teaching staff, programme leaders, administrative staff supporting quality enhancement, industry practitioners/employers, students, not least institutions can also utilise a variety of digital tools in different contexts to facilitate engagement and strengthen collaboration, thereby contributing to continuous enhancement pertaining to learning, teaching and assessment.

Digital Tools to Facilitate Stakeholders Engagement

<u>Programme Leaders, Teaching and Administrative Staff</u>

QE can only be deliberated and converged towards maximising students' benefits with active engagement of programme leaders and teaching staff in daily programme management, learning and teaching activities, not least the assistance provided by administrative staff (Williams and Kane, 2009). During the course of QE, these internal stakeholders may encounter questions and may require different degrees of support.

Artificial Intellegent Chatbots

Over the past decade, with the advancement in artificial intelligence (AI) algorithms, such as natural language process (NLP) and machine learning (ML) technologies, AI chatbots has been developed with significant improvements (Ask, Facemire and Hogan, 2016). AI chatbot is able to recognise informationm, learn from data, understand human communications in spoken and written forms, forecast outcomes and communicate back to human using the language that is

understood by human (Rahman, Al Mamum and Islam 2017; Uliyar 2017).

In higher education, chatbots have been used to help students with admission applications, enrolmment and class scheduling (Page and Gehlbach, 2018; Dennis, 2018). It also helped to address students' questions on learning and other enabling resources, and send students reminders about important dates, thereby increasing learning motivation and retention (Dennis, 2018; Lin, 2012). AI chatbots hence gives faculty and staff the ability to be more effective and efficient when communicating with students and improving overall learning experience.

AI chatbots are able to serve as helpdesk support and assist academic and administrative staff to nevigate through QE. AI chatbots are 24/7 available, even during school holidays, and are able to provide instant answers to multiple users as regards questions on programme development, teaching and learning, programme management, programme monitoring and review. Most importantly, since AI chatbots can provide consistency in answering questions of the same kind, it can also help maintaining compliance to quality assurance mechanisms.

Big Data Analytics

Big data comprises of 3 Vs: high-volumn, high-velocity nd high-variety data (Kitchin, 2013). Big data therefore draws from a multimple sources and transactions and therefore contains valuable patterns and information for eventual analysis. Analytics, in the form of business intellegence (BI), is defined as a set of technologies, processes and tools that use data to predict likely behaviour by individuals (Mashingaidze and Backhouse, 2017). Big data analytics can therefore deliver richer insights and uncover hidden parttens and cause-effect relationship (Minelli, Chambers and Dhiraj, 2013).

Many VPET institutions worldwide have adopted big data analytics to manage enrolment, transform alumni engagement and financial aid administration. Equally important, it has been used to collect data on student performance, identify effective teaching methods and increase students success (Attaran, Stark and Stotler, 2018).

In terms of QE, since big data anlytics can easily categorise data on detailed sub-levels selected time periods or any other pre-defined categoties, it can be used to facilitate internal and external reporting and complicance to the requirement of external accreditation bodies. For example, staff could easily provide data and reports related to teaching and learning, the achievement of students and their academic progression, faculty applied research and knowledge transfer, finance and other enabling resources.

Collaborative Real-time Editor

A coallborative real-time editor refers to a web application and/or software that enables simultaneous editing of the same digital file by more than one party. With the abundancy of open source and web-based editor available nowadays, such editor has been widely used by students to prepare team assignments and projects.

To further facilitate communication, streamline review, enahnce team collaboration and productivity during each facet of QE, collaborative real-time editor under an encrypted secure institutional environment shall be employed so that the staff concerned can contribute without the need to travel across different geographic locations or wasting time to send files back and forth among different parties.

Industry Practitioners/Employers and Students

One of the merits of VPET is the engagement of industry practiners/employers, professional associations, graduates and students so that they can all contribute to continuous review and enhancement of programme for a set of agreed outcomes that meet the needs of the ever-changing society (Kwok and Yuen, 2021). In spite of the increasing importance of stakeholder engagement, each of these stakeholders are often managed seperately by different levels of the institution, programme team or teaching staff. For effective QE, it is always important to better manage these stakeholder database, maintain close communications, facilitate interaction and synergy.

Stakeholder Engagement System

A stakeholder engagement system (SRM) is widely used as a knowledgebase in commercial settings to build long-term effecitve partnership. A stakeholder engagement sytem can track conversations and communications, produce surveys, manage feedback, and manage events.

While some VPET institutions have consolidated multiple tools, such as Outlook (email) and spreadsheets (database), to update individual stakeholder in central files, save time and money, SRM can be a standalone software. The SRM allows institutions to assign acess right to the staff concerned while visualising all of the interactions made, track, analyse and understand the engagement with the stakeholder including their needs, preference and concerns.

In the context of QE, SRM allows institutions to invite regular feedbacks from the stakeholders concerned accordingly to a prescribed schedule. It also helps to record and track all engagement, comments and suggestions, not least commitments of any specific stakehdolers, while sending them notifications/messages on the actual improvement actions made. All these functions will allow various internal (e.g. students) and

external (e.g. employers) stakeholders to contribute to the improvement of the provision of education in VPET and/or higher education establishments.

VPET Institutions

VPET institutions can adopt different technologies to anchor QE in addition to prioritising it. Apart from developing or deploying the above-mentioned digital tools to facilitate the various facets of QE, institutions may consider utilising technologies to build capability for staff, allowing them to effetively immerse in QE in daily activities while preparing for challenges they'll face in the future. Blockchain could also be adopted for recording, tacing and sharing confidential records that are required by external accreditation bodies.

Bite-size E-learning for Capbility Building

Institutions can facilitate stakeholders to collaboratively contribute to QE, especially the internal ones, by helping them to develop a clear understanding. Because of the variety of stakeholders invovled, and the different roles they may assume, traiditional face-to-face sharing seminar/workshop or development programmes may not be the most effective ones. Instead, bite-size online capability building modules focusing on one or two tightly defined learning objectives and breaking down QE into digestible chunks are more suitable for stakeholders to learn through at a pace that suits them.

Bite-size e-learning is considered to be more effective and engaging as it increases learner retention, quickly responds to evolving environments and practices, and are more flexible. Hence, it has been adopted in various contexts, both in higher education and in business settings targeting at learners from all walks of life.

VPET institutions can therefore shift long development courses to bite-size e-learning modules to help stakeholders gain/refresh/deepen understanding they need to acheive QE goals. Stakable content on QE also makes it easier for stakeholders to savor every lesson step after step, which is something not possible with lengthy materials.

Blockchain Technology

A blockchain is a distributed database that chronogically stores a chain of data packed into seal blocks in a secure and immutable manner (Zheng *et al*., 2017; Turkanovic et al., 2018). Since the chain of blocks is continuously growing, new blocks are being appended to the end of the chain whereby each new block holds a reference to the content of the previous bock (Zheng *et al*., 2017; Turkanovic et al., 2018).

Growing number of higher education institutions are using blockchan technology in different ways. These include issuin digital credentials, sharing of verified copies of student qualifications with other institutions for articulation and employers for recruitment purposes (Turkanovic et al., 2018; Lizcano *et al*., 2020; Kamišalić et al., 2019).

The ability of blockchain technology to improve record-keeping has made it suitable for VPET institutions to store accreditation evidences, including but not limited to student records, meeting records and graduate survey results. Since blockchain technology can also be used to create virual records, such as student performance, it may also be use to facilitate seamless inter-department/faculty and inter-institution sharing/submission, thereby achieving efficient strealine processes.

Robotic Process Automation (RPA) Technology

The RPA technology automates certain activities carried out by human beings, mimicks them, as part of performing the human process to robotics (Aguirre and Rodriguez, 2017; Asatiani, 2019; Mendling *et al.*, 2018). It eliminates inefficiencies and reduces the burden and effort of the repetitive and tedious tasks of staff (Aguirre and Rodriguez, 2017; Kumar, Shashi & Prasad, Prabhu. 2020; Novais, 2021).

The RPA technology also helps educators to simplify their works when it is being utilised in student admission, course/class registration, student enrolment, class scheduling, attendance tracking, assessment grading and student performance. It acts like a virtual employee that supports the faculty and academic and administrative staff to provide students with high-quality education administration support.

RPA streamlines and simplifies process to increase efficiency and consistency, saves considerable amount of time and resources, enhances governance and better manages operations and compliance issues for internal quality reviews. RPA also opens up opportunity for QE and adding value to the educational experience; not just for students, but for all institutinal staff in the long term.

Conclusions

QE can only be effective and sustainable when both internal and external stakeholders are invovled and collaborate with each other. Digital tools can facilitate this process if they are probably developed/utilised according to the characteristics and uniqe needs of different stakeholders. The way technology has been used and its effectiveness will determine how effective academic performance is, and how it is perceived by academics, teaching staff, students and other stakeholders (Perrin and Wang, 2021). Given the range of digital tools available, institutions shall holistically consider their deployment and integration to maximise effectiveness and efficiency of QE. Further study is required to identify the value of benefits that digitial tools bring to QE in reality.

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WORKING IN PARTNERSHIP FOR THE EMPOWERMENT OF FEMALE STUDENTS IN ENGINEERING

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Abstract

In Japan, the proportion of female students in STEM is low, particularly in Engineering. According to *the White Paper on Gender Equality 2019*, only 15% of undergraduate engineering students were women in 2018. Furthermore, *UNESCO Science Report 2021* states that this number becomes lower with regard to women researchers in engineering in higher education in Japan (11.1%). This is what we call "a leaky pipeline". As the level of education in engineering increases, the number of women decreases. Consequently, female students lack role models and female leadership in this area, which creates a vicious cycle in terms of gender equality in engineering. As for National Institute of Technology (KOSEN) in Japan, the proportion of female students who entered KOSEN has increased gradually year by year, but it still remains low with only 23.3 % of female students making up the total number of first year students in 2021. However, the proportion of female students varies across 51 different colleges. In order to increase the number of female pupils who choose a career path in STEM, especially in engineering, female students in some KOSEN have been volunteering at local schools to teach programming to younger generations. Their goals are to foster interest in STEM and introduce children early to female role models. In our workshop at ISATE 2021, we shared reflections on a study abroad capacity building initiative undertaken in the UK in 2018 and discussed the possibility of working together on ways to empower female students in STEM in the future. This was designed to support these female students undertake their volunteering work; to build capacity of female students in language and communication skills, leadership, and teaching ICT skills to children. The purpose of this paper is to discuss how we built an international partnership; inter-college networks among some KOSEN in Japan; and as a result of the workshop at ISATE 2021, how female students' capacity was enhanced through interdisciplinary learning in English, communication skills, leadership, and teaching skills in 2022.

Keywords: *female empowerment, capacity building, international partnership, inter-college networks, interdisciplinary learning*

Introduction

In Japan, the proportion of female students in STEM is low, particularly in Engineering. According to *the White Paper on Gender Equality 2019*, female students account for only 15% of undergraduate engineering students in Japan. Furthermore, *UNESCO Science Report 2021* (p. 658) states that this number decreases with reference to women researchers in engineering in higher education in Japan (11.1%). This is what we call "a leaky pipeline".

Some students at a national college of technology in Japan decided to change this situation and have been working as volunteers to increase the number of female students who enter their college. They set up a chapter of a student-run international volunteer organisation which was established by Australian university students in 2008 for the purpose of increasing the number of female students in the STEM fields. The student volunteers, "Robogals Kagoshima", teach programming to younger generations at local elementary schools and junior high schools to foster interest in STEM and introduce children early on to female role models. In order to enhance their capacity in communicating with children and teaching ICT skills to them more effectively, a capacity building programme was designed by university and college partners in Japan and the UK.

The purpose of this paper is to discuss how we built an international partnership; inter-college networks among some KOSEN in Japan; and as a result of the workshop at ISATE 2021, how female students' capacity was enhanced through interdisciplinary learning in English, communication skills, leadership, and teaching skills in 2022.

The Empowerment of Female Students in Engineering in Japan

Our Workshop at ISATE 2021: In our workshop at ISATE 2021, we shared reflections on a study abroad capacity building initiative undertaken in the UK in 2018. This capacity building programme, understood through the lens of empowerment (e. g., Eger et al., 2018), was conducted with university and college partners in Japan and the UK. Students from two national colleges of technology in Japan participated and four teachers from different colleges joined as faculty observers. The objectives were to build capacity of female students in language and communication skills, leadership in organising workshops for children, and teaching ICT skills to children. In our interactive workshop in 2021, we discussed the possibility of working together on ways to empower female students at KOSEN in the future (see Tsukazaki, 2021).

Our Programme in 2022: As a result of our workshop at ISATE 2021, we established networks with some colleges of technology in Japan. With the help of our international partnership since 2018, we planned to hold workshops for the empowerment of female students in engineering. Students from six national colleges of technology attended this programme in March, April, and May in 2022. The duration of each session was an hour. An introductory session was held in March in which students at each college made a presentation to introduce their college, major, grade, and project. This introductory session was necessary as the students have almost no opportunity to meet students from other colleges and they are studying different major, i.e., (a) mechanical engineering, (b) electrical and electronics engineering, (c) chemistry, biochemistry and materials science, (d) information technology, or (e) maritime technology. In addition to students' presentations, preview videos of lecturers at Queen's University Belfast and South Eastern Regional College in the UK were broadcast to students to introduce their upcoming sessions in April and May.

International Partnership

South Eastern Regional College: South Eastern Regional College (SERC) has eight campuses located in the south eastern area of Northern Ireland (NI) in the UK. SERC's mission is to shape the community, by promoting an innovative and entrepreneurial society through maintaining an inclusive learning environment, which will empower and enable individuals and businesses to fulfil their ambitions. SERC's international development strategy centres around developing mutually beneficial partnerships to support student and staff exchanges, share best practice pedagogy, facilitating teacher upskilling, and securing collaboratively funded or commercial projects.

In the 2022 programme, two Lecturers from SERC participated in the workshops with the Japanese students. Aine McGreeghan presented an overview and outcomes of a Women In Engineering project undertaken by SERC and another project promoting engineering to Primary School children in Northern Ireland. As Ms McGreeghan had previously worked as an engineer she participated in a Q & A session in which the Japanese students asked questions about her experience and her perceptions of women in engineering. Some of the attendees asked their questions in English and Ms McGreeghan appreciated this effort. Other questions were asked in Japanese and were translated. Questions included: "Is a PhD required to become an engineer? Are there fewer female engineers in some areas of engineering than others? How do you motivate a student who is not interested in robotics?"

The other session provided by SERC was delivered by Heather Gyle, and highlighted the range of free, readily available apps to engage and inspire children in schools. SERC felt the timing of the presentation worked well and the length of the presentation was appropriate for the participants. To improve the session, and ensure the content is pitched at the correct level, more information about the attendees and their expectations for the session would be necessary. This would enable presenters to tailor make the training to suit the interests of the students and professors. All SERC staff believe the project is an excellent example of partnership working, with students and professors from Japan and Northern Ireland learning from each other and addressing a common issue.

Queen's University Belfast: Queen's University Belfast (QUB) is a research-intensive Russell Group university in the UK. It is a member of the Athena Swan Charter, an international framework which supports the advancement of gender equality within higher education and research. QUB has been a member of the Charter since its formation in 2005 and currently holds a prestigious Athena Swan Silver Award as well as "14 School Awards comprising 3 Gold, 6 Silver and 5 Bronze" (Athena Swan at Queen's, 2022). Therefore, it was of great significance for "Robogals Kagoshima" student volunteers at KOSEN to study abroad at QUB.

Dr Aisling O'Boyle at the School of Social Sciences, Education and Social Work at QUB has supported "Robogals Kagoshima" since 2018. In the study abroad capacity building initiative undertaken in the UK in 2018, she planned her sessions in order support female volunteers to develop their leadership and classroom communication skills in English. Here is her four-step plan: (1) Getting to know a different institution; (2) Getting to know our shared purposes; (3) Getting to know each other; and (4) Getting to work! In the first step, Dr O'Boyle introduced herself to Japanese students, and then, they took a guided campus tour with International Student Ambassadors at QUB.

In the second step, in order to situate students' volunteering work in a wider context and understand their own leadership roles, they learned about innovative education and international volunteering projects in the UK. In the third step, Dr O'Boyle took advantage of her lunchtime with the students. By sharing social spaces, the goals were to better understand each other's intentions and motivations and to minimise language anxiety. Finally, in the fourth step, the students practiced their teaching skills and communication in English for children and young people in a three-hour workshop. In her session with students at KOSEN in April in 2022, her goals were to develop students' skills in English and build confidence in using English. This session will be discussed in detail in the later section of this paper.

Results and Discussion

Let us look at the participants' feedback concerning their learning experiences in this programme in 2022. Twenty-three students attended our session on 26 April and nine Japanese professors observed it. In our session on 11 May, twenty-six students attended and eleven professors observed it. Some students attended all the three sessions including the introductory session in March, and others attended once or twice due to personal circumstances. To participate in the sessions, some students joined individually online using with their own computer, while others joined in-person with other students in a classroom with the help of the professors in their college (see Figure 1).

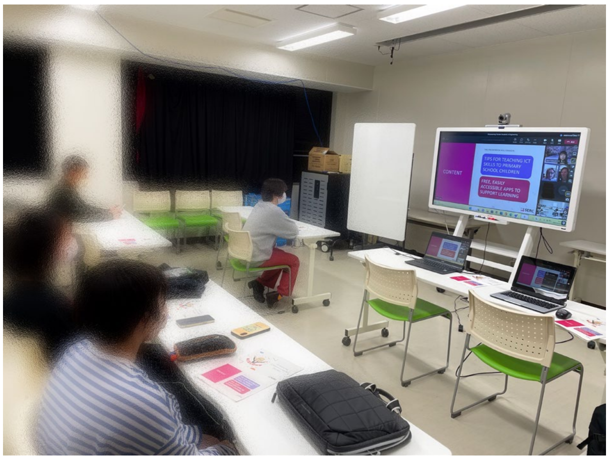

Figure 1: Some Students Joined the Sessions in a Classroom

After each session, students reflected on the session completing a questionnaire measuring: (1) their satisfaction, (2) perceptions of how much they learned to build their capacity, (3) reported changes in their confidence, and (4) possibilities for participating in sessions in the future. Although we could not get feedback from five students in April and one student in May, the total numbers of students who gave feedback to us total eighteen in April and twenty-five in May.

Let us look at the results one by one. Firstly, Table 1 shows the students' feedback regarding their satisfaction. As the table shows, most students were satisfied with the sessions in both April and May. Thirteen out of eighteen students and nineteen out of twenty-five students gave the highest scores to the sessions.

Table 1: Satisfaction

	April	May
★★★★★	13	19
★★★★	4	3
★★★	1	3
★★	0	0
★	0	0
Total	18	25

Secondly, Table 2 shows the students' evaluation for capacity building. They were asked to evaluate how much they had learned. This question was intended to measure whether they were successful in their capacity building. More than half of the students in each session gave the highest rating for how much they learned and built capacity.

Table 2: Capacity Building

	April	May
★★★★★	10	14
★★★★	5	6
★★★	2	5
★★	1	0
★	0	0
Total	18	25

Thirdly, judging from the students' feedback in Table 3 on their willingness to participate in future sessions, we may be able to say that we succeeded in providing enjoyable sessions for the participants. All participants except only three students in May said that they would like to join our sessions for empowering female students in the future.

Table 3: Possibilities for Participation in the Future

	April	May
Yes	18	22
No	0	0
I do not know	0	3
Total	18	25

Finally, after each session, we asked the participants if there was a change in their confidence. As Figure 2 shows, thirteen out of eighteen students increased their confidence after the session in April, although three students became less confident and there was no change

in confidence for two students. We should note that two out of thirteen students became much more confident.

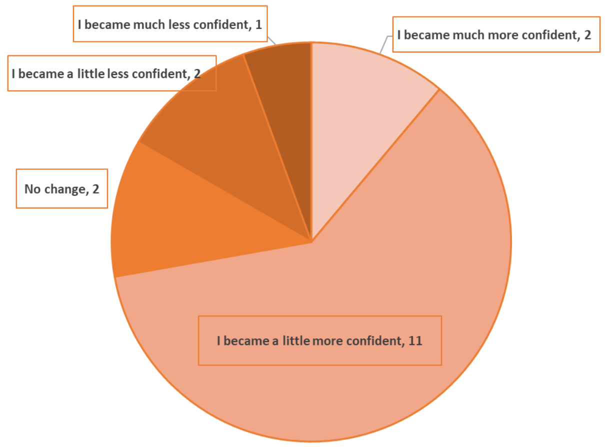

Figure 2: Confidence after the Session in April

Similarly, after the session in May, twenty-one out of twenty-five students increased their confidence, whereas two students became less confident and there was no change in confidence for two students as shown in Figure 3. Again, attention must be directed toward the four students who became much more confident by attending the session.

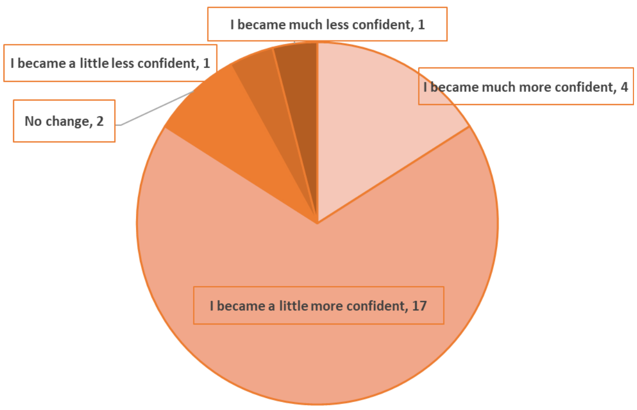

Figure 3: Confidence after the Session in May

It should be noted that the atmosphere of the session in April lowered Japanese students' anxiety in expressing themselves even in a foreign language. Foreign language anxiety (FLA) is a well-recognized affective factor in language learning (e.g., Horwitz, 1986). Causes of anxiety can include fear of not knowing how to say something in English, speaking in front of others, being called upon by the teacher, and worrying about mistakes (Williams and Andrade, 2008). Such anxiety provoking situations were taken into consideration and it was pointed out by a faculty observer that visual aids and easy questions enabled students even with low ability in English to understand the sessions.

In the communication part of the session in April, the targets were to develop students' skills in English and build confidence in using English (see Figures 4 and 5). For example, the lecturer taught how to add information to introduce themselves in English, which could be used when teaching younger students through the medium of English in volunteering projects or for their future communication with their fellow international students or colleagues. When some of the students introduced themselves voluntarily as demonstrations, they looked eager to speak English and talk with the lecturer.

Figure 4: Classroom Language (Dr Aisling O'Boyle)

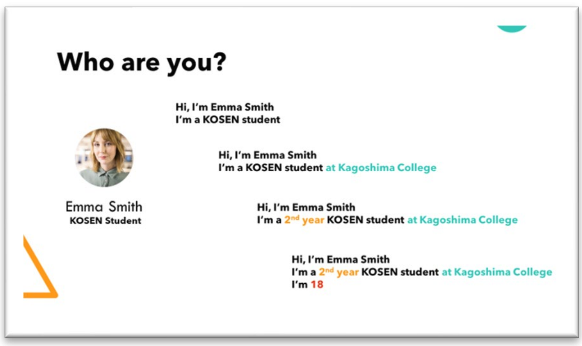

Figure 5: Self-Introduction (Dr Aisling O'Boyle)

In addition, the sentence "we are all language learners" told by this lecturer was very impressive and motivating for the participants including faculty observers. Some student said in the questionnaire that she learned how to engage with others, particularly beginners, in teaching ICT skills to them as a volunteer. Another student said that she learned how to teach and talk to children in order to foster interest in ICT (e.g., Figures 4 , 6 and 7).

One professor who observed the sessions stated that the sessions were very effective in that there were many interactions between the students and the lecturers. Whether it was spoken communication between the lecturers and participants or written communication in the chat in Microsoft Teams meetings, they kept interacting with each other during the sessions.

When they were practicing introducing themselves (see Figure 5), some of them wrote a sentence to introduce

themselves in the chat in Microsoft Teams meeting. Moreover, when the lecturers were introducing tips for teaching ICT skills to elementary school children, all participants engaged in using the apps (see Figures 6 and 7). It was interesting that the lecturer took a poll with an app: "What might help encourage more female engineers".

Figure 6: Top Apps and Websites (Lecturer Heather Gyle)

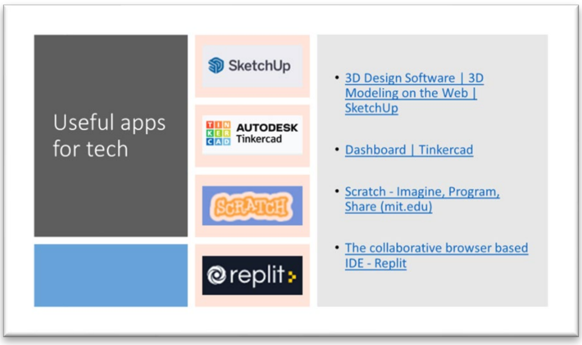

Figure 7: Useful Apps for Tech (Lecturer Aine McGreeghan)

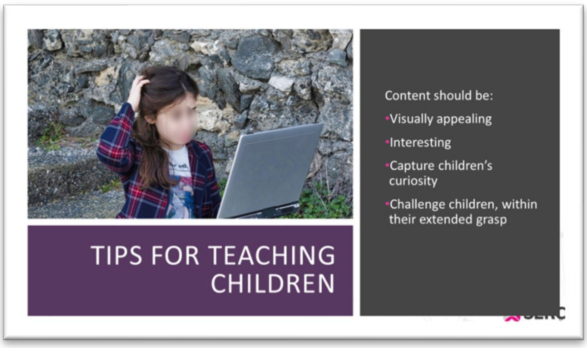

Figure 8: Tips for Teaching Children (Lecturer Heather Gyle)

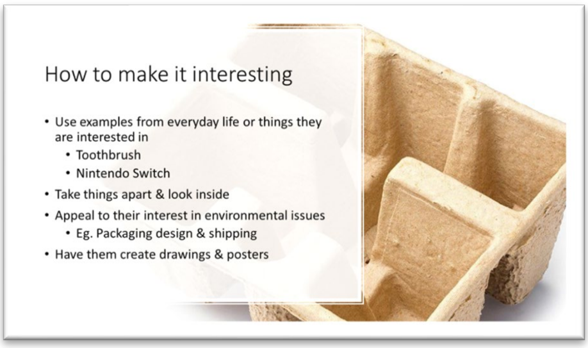

Figure 9: Tips on Making Workshops Interesting (Lecturer Aine McGreeghan)

It was a pleasant surprise for the Japanese organiser that some students did not hesitate to ask questions to the lecturers in English. This is because Japanese students tend to avoid standing out in the classroom and remain silent, even more so when speaking in a foreign language. This also inspired other participants and made them decide to ask questions themselves in the next session. As a result, students asked many questions in the next session in May. The students who attended the previous session in April were ready to ask questions in May, which led to an endless question time with the lecturer. For those who could not speak English confidently, they spoke in Japanese and the organiser translated their questions into English so that they could join the conversation and got all the information that they wanted to learn from the lecturers. One of the KOSEN professors points out that once a couple of students started asking questions, this triggered enthusiastic questions from other students. He also states that he wants his students to be brave and enthusiastic enough to be the first speaker.

One of the lecturers delivering the sessions used to work as an engineer in industry. It was a great opportunity for the students to meet a female role model in engineering. In Japan, the proportion of female researchers in engineering in the business sector is only 5.6% and that in university is 11.1% in 2017, according to *UNESCO Science Report 2021* (p.658). Judging from these numbers, there is no exaggeration that students have very little opportunity to meet female role models in engineering in Japan. This may be one of the reasons why the participants could not stop asking questions to the lecturer. The students took advantage of this great opportunity, which was highly appreciated by Japanese professors at their colleges. In addition, the lecturer also introduced the students to her own female role models in engineering when she answered one of the students' question.

Here is some feedback from the KOSEN faculty observers: (1) It would be helpful if the students could discuss with students from other colleges; (2) We would like to have longer sessions with international partners in the UK; and (3) frequent sessions all through the year.

All feedback was positive and full of possibilities to make this programme more motivating and inspiring for female students at KOSEN.

Finally, although the students could not have face-to-face communication, we can conclude that the participants made the most of these online sessions. As Ozel et al. state, “a learning environment which offers enjoyment, creative and interesting activities attracts students’ attention and raises their motivation towards learning” (Ozel et al. as cited in Hidalgo- Camacho et al., 2021).

The students had ample interactions with the lecturers in the UK without being too shy or afraid of making mistakes in speaking English and asking questions. Furthermore, the students learned from each other. As a result of attending the sessions with students at different national colleges of technology, they learned that there are various areas in engineering. They also learned about different perspectives from other students' questions. In this way, it was a great opportunity for them to meet engineering students with different majors and backgounds. As Milheim puts it, “teachers have the responsibility to seek for ways to improve the online learning environment to motivate, engage, inspire students, and make them feel satisfied” (Milheim as cited in Hidalgo- Camacho et al., 2021).

Conclusion

Judging from the feedback from the participants, they were satisfied with our capacity building programme in 2022. Despite the length of each session, this programme enabled the students to learn communication skills and teaching skills and tools that they will be able to utilise in volunteering. More importantly, it is notable that the sessions increased most participants' confidence. One of the professors who observed the sessions said in the questionnaire, “It is important for us to keep encouraging our students”.

In the future study, we would like to improve our programme based on the participants' and observers' comments and suggestions. It will be very beneficial for female students at National Institute of Technology, (KOSEN), if female students from other colleges as well as those who attended the present programme in 2022 can join our future programme and study abroad together.

Acknowledgements

The authors would like to express our deepest gratitude to President Isao Taniguchi at National Institute of Technology, KOSEN who have kindly supported this programme for years. We would also like to thank professors at NIT, Kagoshima College, Sasebo College, Toyama College, Okinawa College, Toba College and Hachinohe College. Last but not least, we are deeply grateful to Lecturer Heather Gyle and Lecturer Aine McGreeghan at South Eastern Regional College for inspiring our female students at KOSEN in their sessions.

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A Globalization of Student Dormitory at NIT (KOSEN), Fukui College

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Abstract

A student dormitory at National Institute of Technology (NIT, KOSEN) is one of the most appealing points to Junior high school students. It is because dormitory at KOSEN is recognized as having educational aspects and can accommodate many KOSEN students who is difficult to go to KOSEN for long distance. In short, a dormitory at KOSEN has a different system from a boarding house and university dormitory. Furthermore, the headquarters of NIT strongly promotes the globalization of student dormitory at KOSEN now. Considering this policy, as main purpose of our presentation, we focus on the globalization of student dormitory at KOSEN, Fukui college. Three main aspects of an ideal methodology are mainly discussed in our presentation. First, the outline of student dormitory at KOSEN is given, and especially its function as an educational institution is stressed. This also explains the present situation of international exchange at NIT. Second, the analysis of the great influence of COVID-19 upon student dormitory is shown. This virus has severely restricted the previous life style of student dormitory, and naturally, KOSEN has faced the very difficult management of dormitory. We report how we prevented a student dormitory from infection as much as possible. In addition, we trace the way we covered the disruption of relationships between our students. Third, the process of the globalization of student dormitory at KOSEN, Fukui college is indicated in detail. In this process, a variety of autonomous activities of students are especially regarded as most important, and as an example, some of the oriented dormitory students discussed what kind of characteristics are most required for the globalized dormitory, and made a promotion video in English. In short, tackling the globalization of the dormitory can promote the autonomous learning activity of students through practically using English and ICT. This movement affected the whole students of our college. As conclusions, we mention some students received the ministry of education award, and an honourable award in JICA essay contest. Finally, as recommendations, we conclude our future prospects for a student dormitory at KOSEN can contribute to the promotion of the globalization at KOSEN.

Keywords: *Student Dormitory, NIT (KOSEN), Globalization, Student Activities, English Learning with ICT*

Introduction—what is KOSEN dormitory?

In order to explain dormitory system at KOSEN, first, we show a general outline od KOSEN education system. In the web homepage of KOSEN headquarters, the outline of KOSEN is concretely explained:

> KOSEN (has a) five-year engineering education from 15 years old - were established in 1961, in response to a strong demand from the industrial sector to foster engineers who sustained the high Japanese economic growth at that time. . . . Approximately 300,000 students have graduated so far (as of 2004), contributing actively not only in the industrial world but also in the academic sector, as engineers, researchers, managers and so on.

From this explanation, we point out five notable characteristics referring to KOSEN dormitory systems: (I) A big variety of age between students, (II) the unique combination of both high school and college education systems, (III) male students' majority (small ratio of female students) usual to engineering fields in Japan,

(IV) constant foreign students' acceptance, (V) the urgent demand of global education including learning English. As a further explanation, we show a graphic as follows:

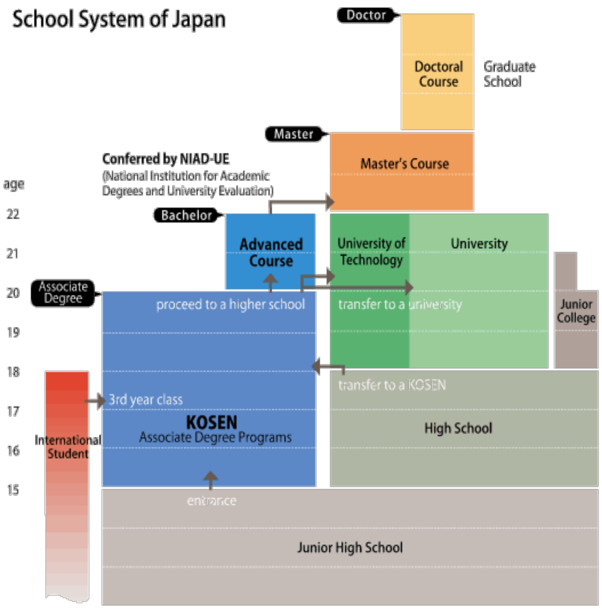


Figure 1. Education System of KOSEN

Under this outline of KOSEN, we give some characteristics of dormitory at KOSEN.

National institute of technology (KOSEN) has 51 colleges nationwide in Japan. All these KOSEN have a student dormitory. Different in their managements from each other, KOSEN dormitory has some common objectives for dormitory: We pick up the three of them. Generally speaking, KOSEN dormitories have been established (I) to enable students living far from college to enter KOSEN without commuting there, (II) to nurture students' humanities through living together directed by teachers. And (III) to fulfill the college objectives of education through the so called blending of doromitory and commuting students each other. In addition to these, the Head Office of KOSEN strongly promotes KOSEN dormitory to develop global and internationalized dormitory. It can be said that those three main objectives for KOSEN dormitory have common goals with global education. In this paper, we aim to show the process of KOSEN dormitories' globalization, so at first we examinine these points of view with the great influence of the spread of COVID-19.

An Outline of KOSEN Dormitory

Originally, since its foundation in the 1960s, each KOSEN has founded and maintained dormitory. We have already pointed out the three main general objectives for KOSEN dormitory. At first, as a concrete example, we show the case of our college (NIT KOSEN, Fukui college, its nickname 'Seibu-ryo'). We give a brief overview of our dormitory from the college directory

> The student dormitory, Seibu-Ryo, has a capacity of 248 at present. There are four dormitory buildings for our students and Central building for administration and dining: East, West, South and North. Men and male foreign exchange students reside in the eastern, southern and western dormitories. The northern dormitory is home to women and female foreign exchange students. The dormitory buildings are characterized as educational facilities of the school. Teachers will serve as resident advisors and stay at the dormitory on a rotating schedule. They respect the students' rights and uphold the students' responsibility of living in the school dormitory community. In order to further promote internationalization, we are currently constructing a new International Dormitory with the aim of opening it in fiscal 2022

The number of students living in dormitory is about one-fifth parts of the whole students (about one thousand) in our college. A scale of dormitories, the number of students living in dormitory or facilities, differs from each KOSEN college, but our dormitory is a standard of comparison between all the KOSEN colleges. The ratio of male to female students is 5:1, and there live around 40 students in each grader (15 to 22 years' students). There are two dormitory superintendents weekdays, and one weekends. The teaching staff concurrently serves as dormitory superintendents. There also is one special division in college organization in charge of dormitory affairs constituted by some of the teaching and the administration staff. In our college the number of the division is about 7 teachers and 2 clerical workers. Although KOSEN dormitories are very much impressed with its educational respect and differ from the level of university dormitory especially as to the students' variety of age, it can be said that there is not enough staff for dormitory. That is why, traditionally, KOSEN dormitories have been maintained partly by the bond or close relationship between the senior and junior dormitory students. However, the seniors do not have the same right as teachers do, so excessive dependent on the seniors as to the maintenance of the dormitory can cause serious problem such as bullying or the hidden unfair rules made and kept by the seniors without permission of teachers. As time has passed by, these styles of dormitory are now often criticized and obliterated, so we have faced to modify them and need to meet to the standard values of the present time.

As improvement measures, we set our goal of constructing globalized dormitory. In short, globalization is our key issue, and through the spread of this value, not only dormitory but also the whole college could be activated, we think. To achieve this goal, main three steps are prepared: first, to take questionnaire to the dormitory students, second to offer various opportunities to dormitory students for realizing their own autonomous activities, and third through restoring the lost relationship between the dormitory students by COVID-19, we set another new goal for constructing new global dormitory completed in September 2022 which could be a valuable

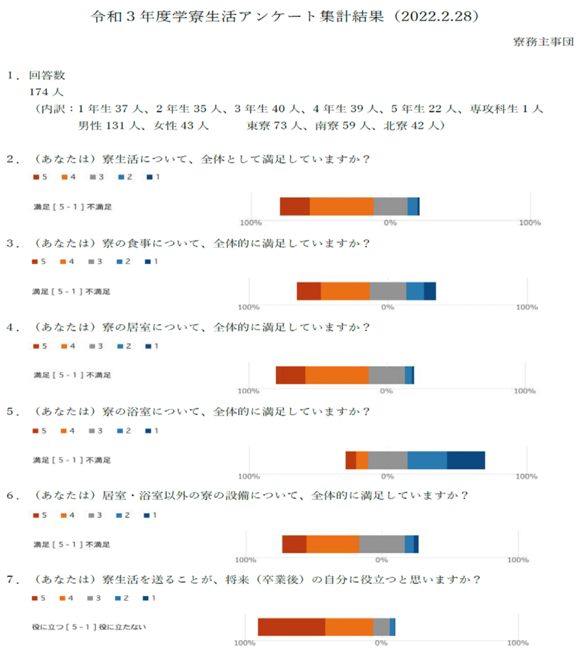
symbol as KOSEN dormitory for the new generation and age with or after COVID-19.

Materials –Questionnaire to the dormitory students

In order to focus on the matters we need to face as to the KOSEN students' dormitory life, to the dormitory students, we conduct annual questionnaire about their dormitory life every year. Here we show the latest results as a first step to the focus of interest the dormitory students hold. Nornally we set around ten questions and free comments about the dormitory life. Their evaluations are scaled five (high) to one (low). Its main topics vary from meals, common facilities such as bath, dining room, learning common room and so forth. Some characteristics are extracted as below. There got the low points as to the question of meals, bath, the relationship between the students

Some free comments are severe, especially about the serving of meals. And a few students felt that the relationship between the senior and the junior students is insufficient. We hypothesis that these points are closely associated with the severe restriction caused by the spread of COVID -19. As solution, we set an idea of globalization as key elements to solve these problems.

Focusing on these issues which the dormitory students worry about, we show the practice of our dormitory to deal with these issues. We try to set concrete opportunities for dormitory students to create their own autonomous activities as much as possible. Roughly there are the three steps to activate our dormitory by the students themselves under the notion of globalization: first giving an OB lecture, second volunteer of cleaning, and third making promotion movie of dormitory and posting the movie video on YouTube. Finally, we trace a definition of globalization in KOSEN dormitory. The below is an outline of the results of questionnaire.



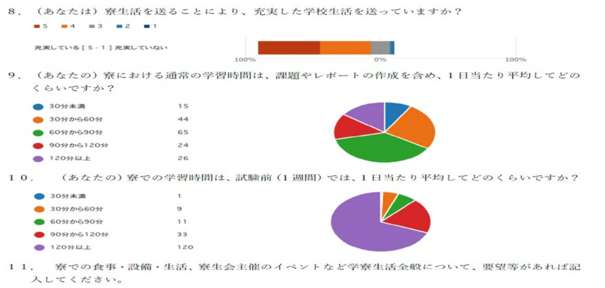


Figure 2. The Results of the Latest Questionnaire

Methods (I)

As we said, considering the awareness of era with Covid-19, we have done various kinds of activities for dormitory students. As getting started, we set a OB lecture to the whole students, teaching and clerical staff of Fukui Kosen.

TAMURA as the president of Fukui college planned to give the students a special lecture by a dormitory graduate very famous in IT business. The lecturer, Dr Mineki Okura, is one of the founders, and going to become the president of the private KOSEN college "Kamiyama Marugoto KOSEN" (https://kamiyama-marugoto.com//)" next Spring in 2023.

In this special lecture, Dr Okura gave a unique lecture about the concept of this ideal KOSEN and of course, the students earnestly listened to him. They were greatly inspired with his story, and were able to think about their own dormitory. It can be said that Dr Okura as a very influential OB of dormitory made the active students realize how important they think about the image of the future dormitory by themselves.

Some of the students asked Dr Okura of the meal serve system there. In Kamiyama KOSEN, the meals of dormitory are going to be served under the system of "with local production for local consumption. They became really interested in this system, and thought about the realization of this style of meal serve even in their own dormitory. In fact, two years ago, just before the spread of COVID-19, a cooking lecture was held in dormitory, and invited some local people as lecturers. As a result, the dormitory students were inspired with this OB leture, and tried to bring back a cooking lecture. The cooking lecture is going to be held this Autumn.

Figure 3. OB Lecture (June 3rd 2022)

Methods (II)

Although holding events at dormitory is severely restricted in the spread of COVID-19, dormitory students

and the staff tried to seek an able event at dormitory, so after discussing between them, we agreed to hold a cleaning of dormitory and local area around the site of dormitory as volunteer activity. It can be a kind of local contribution. This activity was also reported as an article in a nationwide a newspaper. As a result, the volunteer spirits of dormitory students certainly enhanceed the presence of KOSEN all together including Fukui KOSEN.


日経産業新聞
我が校の一押し
草刈りのボランティア
福井高専
国際高専
サル対策で最優秀賞
岐阜高専
人命救助で表彰

Figure 4. An Article in the Newspaper (*NIKKEI BUSINESS DAILY* November 30th 2021)

Methods (III)

Next, we explain some demonstration to enhance and reinforcet information transmission capacity using ICT.

Some dormitory students autonomously created movie introducing dormitory institute worldwide. Their activity certainly promoted the globalization of dormitory. We show the process of creating movie.

They posted their movie on YouTube, and enabled the people all over the world to watch this movie, and enables them to know the presence of Fukui KOSEN. (https://www.youtube.com/playlist?list=PLfR9052B_ZQu-_DOQPAY2SckqGsPHGKjh)

TAMURA as the president, and FUJITA as a vice president of our college gave many valuable opportunities and raised fund to students in which students themselves were able to plan any idea to improve school life autonomously. This event is called "Galileo Contest in Fukui KOSEN". Some of the dormitory students made a team with commuter students, and applied to this contest. We extract the main objective set by those students:

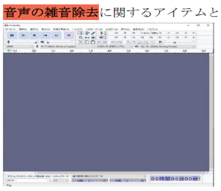
> The videos were created by the members who joined "Introducing Fukui KOSEN to the world!". The purpose of this project was to create videos to introduce our school in English. Up until now, Fukui KOSEN did not have sufficient information for international students from the students' viewpoint. Therefore, we have wanted to send information about our school life that we think future international students want to know. Hopefully, the videos will make them interested in Fukui KOSEN and the number of international students will increase.

The titles of movie contents they made are as follows:
(1) A day of a dormitory student at Fukui KOSEN
(2) An introduction of "Seiburyo(=dormitory)
(3) An interview with international students

Many valuable interactive activities were performed on the WEB by *Teams*. We show the two examples. The first is a feedback about the upload of from teachers, FUJITA. The second is that one student gave the information of the way to remove the noise. In this message, the sender explained about the free soft "Audacity" which enables the users to edit the movie clearly without noise. They also made a poster as belows:

[2021/01/17 20:55] 藤田 卓郎_福井
動画（第一案）のアップロード
第一案の動画を stream にアップロードしました。どの動画もよくできています（予想以上！）。ただ、まだまだ改善できる点もあると思います。英語部だけ閲覧できる状態にしてありますので、良いところと直したほうがよいところを率直に書いてよいものにしましょう。
Stream の動画上にコメントつけましょうか。とりあえずはこの 1 週間でコメント・修正をがんばりましょう。（食堂の動画は学校にしかないので明日にアップします）。

[2021/01/18 20:14] （送信者氏名略）
動画の音声について
音声の雑音除去に関するアイテムとして紹介しときます。



ダウンロード： https://forest.watch.impress.co.jp/library/software/audacity/
参考ページ： https://tokyohappendix.com/audio-tips/audacity
窓の杜 forest.watch.impress.co.jp 「Audacity」無料の音声編集ソフト
これは「Audacity」という録音したり、音をいじれる PC のアプリケーションです。僕は録音を意識していなかったので直してもいまいちでしたが
比較的皆さんきれいに取れていました。しかし気になるところとかもう少し雑音消したいという場合は使ってみてください。突発的な音は難しいですが空調とかの音結構消せます！！下のリンクにダウンロード元と参考ページを張っておくので時間ある方はぜひ！！

Figure 5. An Interaction between the Dromitory Students Posted on *Teams*

Figure 6. A Poster Made by the Students

Notably, active interaction between the commuting and dormitory students were strongly promoted in this learning opportunity.

Another group of dormitory students also made a presentation movie titled as "Fukui Kosen dormitory to the World!" in which they expressed their own ideal image of new global dormitory. At first, they set a theme by their own about the difference between the globalization and the internationalization. From which as a start, they pointed out one big problem by their experience of dormitory life. It was about the difference of food culture. They frankly admitted that they hadn't understood the difference, so they sometimes worried about the smell or taste. As a breakthrough, they emphasized that communal life style should be essential for mutual understanding and nurturing global mind. Naturally, their attitudes were consistent with the ideal concept of KOSEN global dormitory

After all, the dormitory students participating in this learning activity autonomously seek to create their own global dormitory. The followings are parts of their presentation slides: They were able to propose a solution.

Figure 7. A Part of Slides Made by the Students (I)

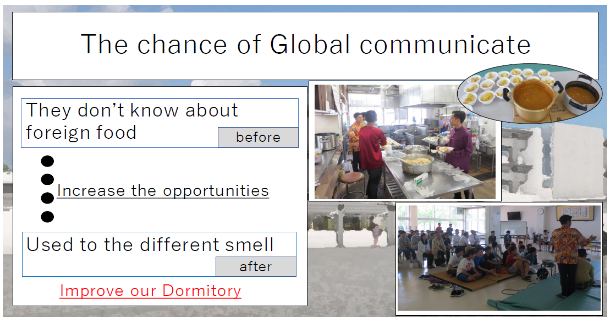


Figure 8. A Part of Slides Made by the Students (II)

Figure 9. A Part of Slides Made by the Students (III)

Pedagogy

From our several practices mentioned above, we propose a way to set a global-mind set for students.

First, the difference between before and after (or with) Covid-19 age should be stressed. In dormitory, traditionally, the strict relationship between the senior and junior dormitory students. However, Presently, this kind of value has become out of date. That is why an alternative way to construct the same relationship between the students in dormitory needs to seek, so under the notion of globalization, we try to offer some valuable opportunities to dormitory students in which the students autonomously reconstruct their relationship and become aware the need to change their mind sustainably. As a result, this could lead to the sustainable future dormitory after Covid-19.

Results and Discussion----for the Future Dormitory

In addition, as some notable main achievements by the students of Fukui KOSEN, a male second grader received prizes for the distinct excellence for getting best grade in English technical writing test held in Novenber 2021 by the Minister of Education, Culture, Sports, Science and Technology last January.

Another, a third female grader and Fukui KOSEN as group also received Hokuriku region's centre director's award and group award each by Japan International Cooperation Agency (JICA). Figure 10 below is a scene of their award ceremony. Further much success would be expected. Thus, interactive cooperation between the dormitory students and commutors needs to be promoted as above. Hereafter KOSEN dormitory can be an important global hub not closed but open to all students

Figure 10. An Awards Ceremony

We would like to mention an ongoing autonomous activity suggested by another group of dormitory students. These students have just applied to "*the Fukui KOSEN Galileo Contest 2022*". They try to ease crowding in the common bath facility and shower room in the dormitory. They certainly acknowledge the restriction caused by the Covid-19 in their everyday life, and become aware of its need to improve the situation. The below is the flowchart suggested by the students. Particularly, we point out that by making this plan, the applicant students are fully aware of the suitable correlation between their dormitory life and speciality (see: Figure 11). Although we cannot the selection result

by now, it can be said that our practical learning approach to dormitory students are sustainably and successfully passed down the junior dormitory students.

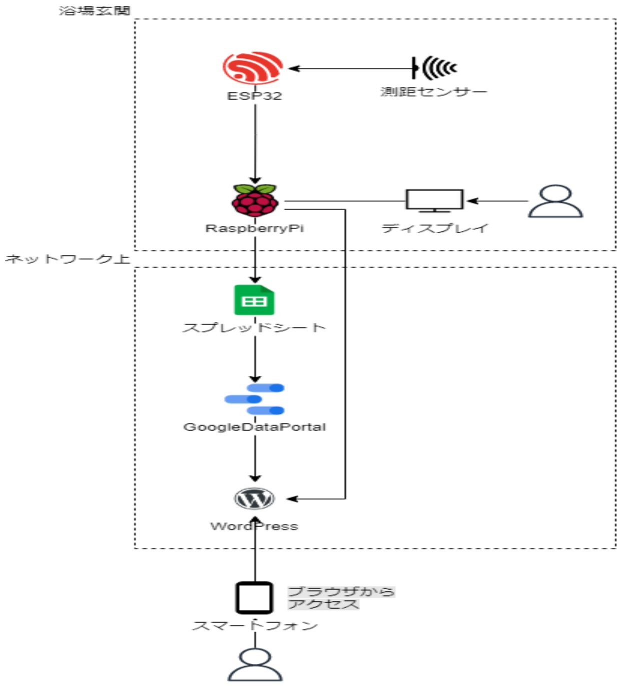


Figure 11. A Chart Proposed by Dormitory Students

Conclusions

Last, we summarize our research as a diagram below.

Figure 12. A Research Diagram made by Serikawa

In this paper, we have thus tried to focus upon the dormitory in KOSEN education system. The followings were the main four points in our assertion: (1) The final goal is the globalization of KOSEN dormitory. (2) However, the influence of the spread of COVID-19 has made it much more difficult to maintain the traditional relationships between the senior and junior dormitory students because of the prevention of the wide and rapid spread of COVID-19. (3) Additionally, the traditional relationships between the two generations have become out of date as compared with the present standard. In short, teachers could no longer depend upon senior students' guidance excessively, so the dormitory students need to be given new opportunity for constructing an alternative relationship between the senior and junior dormitory students. (4) As a solution, we suppose that the notion of globalization could help those dormitory students to think about autonomously the new relationship needed for sustaining their own dormitory lives. Considering the present situation that the Head Office of KOSEN strongly promotes KOSEN dormitory nationwide to develop into globalized and internationalized dormitory, it is indeed the right time now to practice our plan: "globalization of KOSEN dormitory".

Needless to say, after the completion of construction of new building (a newly renovated dormitory) next year, the concrete process of establishment of global dormitory in Fukui KOSEN should be a subjective for our further research.

Acknowledgements

Note that this paper is a part of achievements supported by Chubu Electric Power Company, Incorporated.

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NIKKEI BUSINESS DAILY (*Nippon keizai shinbun*) November 30th 2021.

COLLABORATING WITH EXPERTS TO INNOVATE CYBERSECURITY LEARNING

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Abstract

National Institute of Technology has been working on a cybersecurity project for 51 colleges since 2016. This project has two goals. The first is to ensure all students have sufficient security knowledge and skills. The second is to help information technology students become security specialists. The first goal has been accomplished through faculty development, creation of materials, educating students, student assessment and program evaluation. The second goal encompasses the two most challenging parts of the curriculum. These are how to teach the latest security skills and how to prepare exercises that put students into the role of cyber-attacker. In the field of cybersecurity, attack and defence technologies are advancing so rapidly that it is very difficult, if not impossible, for regular faculty to teach the very latest knowledge and technology. Regular faculty do not face cybersecurity problems daily, so always having up-to-the-minute information is not possible. It is important for students to understand not only defensive technology, but also attack technology and the psychology of cybercriminals. Because this involves students accessing potentially harmful information and techniques, students must be dissuaded from maliciously using their training. Regular faculty can tell students what they should not do, but they do not have the experience necessary to completely convince students to be responsible with their new knowledge and skills. To solve these problems, cybersecurity professionals with direct experience working at the forefront of companies were hired as lecturers. They taught the students methods of penetration, network data collection, hacking and root authority promotion. Importantly, they gained insight into how cyber-attackers think. Students were highly motivated by these exercises. They worked actively and their understanding and performance measurably improved. While these exercises benefitted the students, regular faculty also gained new knowledge and techniques. In the continuously evolving field of cybersecurity, we will continue to actively collaborate with industry professionals to instil cutting edge skills among students and faculty.

Keywords: *cybersecurity, professional, specialist, latest skills, attack, defence, hack*

Introduction

Teaching cybersecurity skills presents numerous challenges stemming from constantly changing technology and cyberspace filled with myriad bad actors. Giving students the opportunity to learn cutting-edge defensive and offensive technologies is problematic for regular faculty because they are somewhat removed from the forefront of cybersecurity, making it very difficult for them to have up-to-the-minute information and relatable real-world experience. This project solves this problem by inviting cybersecurity professionals working in the industry, to teach seminars that prepare information technology students to become security specialists.

Since 2016, the National College of Technology has been conducting a project to systematically introduce security education to 51 technical colleges nationwide. To date, we have decided which security skills students should acquire, created teaching materials, trained teachers, and evaluated teaching practices and assessment. One of the difficulties in the field of cybersecurity education is that technology is rapidly evolving. This makes it difficult for teachers to prepare exercises to teach the latest cybersecurity skills. If preparation is insufficient, the risk of students causing harm to the Internet increases. In an academic environment, it is problematic to create tasks that put students into the role of cyber-attacker for them to better understand the mindset and techniques of cyber criminals. To solve these problems and teach the latest technology, participation of cybersecurity professionals from outside education has been considered. This paper reports our unique approach of having cybersecurity professionals give seminars to the students.

Methods

Participants:

25 Fourth year (first year university) Information security students
One cybersecurity expert
One regular Kochi Kosen faculty member
Information Technology Experiment II

Tasks:
Explore and exploit vulnerabilities in a web application (WordPress) to gain administrator privileges

20 Fifth year (second year university) Information security students
One cybersecurity expert
One regular Kochi Kosen faculty member
Information Security Management

Tasks:
Lecture on information security management, which is considered an international standard

31 Fifth year (second year university) Information security students
One cybersecurity expert
One regular Kochi Kosen faculty member
Network Security II

Tasks:
Lecture on career development for security engineers, including required skills and job descriptions

Preparation

For recruitment, we used an employment website. In a provincial city like Kochi, it is very difficult to recruit people that have cutting edge cybersecurity skills. Due to the increase of online classes in recent years, hurdles to planning and implementing new classes taught by specialized engineers has been lowered even in rural areas like Kochi.

Figure 1: A scene from a seminar class.

This time, we recruited cybersecurity experts as visiting lecturers. This attracted considerable attention because there have not been many previous instances of industry professionals teaching at schools in Japan. More than 50 company experts applied for one position, and finally three people were hired through document review and online screening. The primary motivation for applying was a strong desire to convey their skills to the students.

Previous Implementation

In this lecture, target classes were taught by regular faculty members and cybersecurity experts. The cybersecurity experts designed the classes in cooperation with the faculty members. Faculty members acquired new skills and knowledge while participating in task development and teaching the class. Regular faculty members then created tests and performed student assessment. Working in this way allows regular faculty to acquire new up-to-date technology knowledge while enhancing teamwork skills.

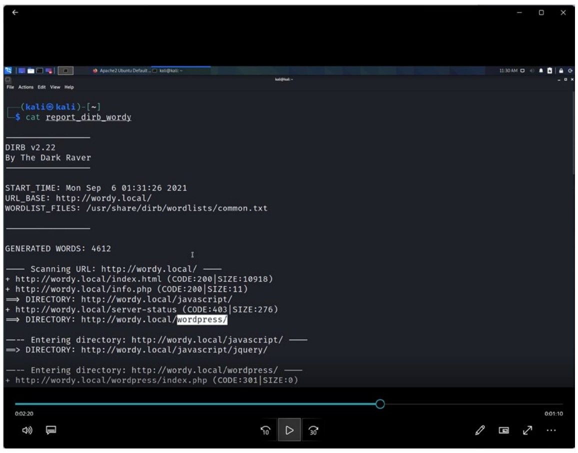


Figure 2: Example of an explanatory video in the security seminar class *Searching for Hidden Web Content.*

In this example, one regular faculty member and one cybersecurity expert from industry taught 25 fourth year the Information Technology Experiment II course. Each fourth-year student participated using a personal computer. The title of this task was *Boot2Root CTF Challenge Hacking Techniques and Route Privilege Promotion*. The contents of this course were also used in a slightly altered form for the fifth-year class. For the exercise, we prepared an exercise environment in advance using the virtual technology *Virtualbox* with WordPress, a popular web server-based content management system installed.

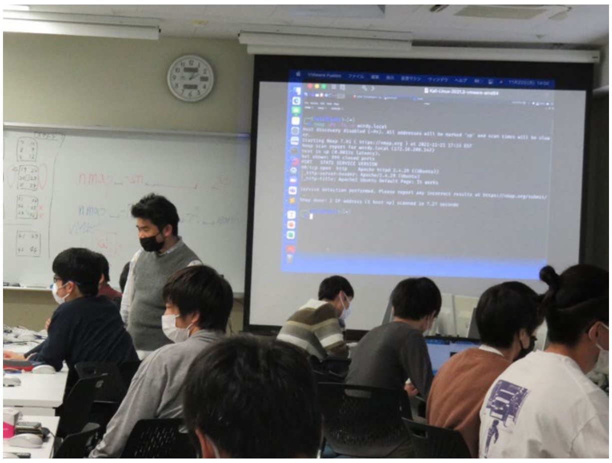


Figure 3: During seminar classes the regular faculty teacher moved aroung the class and provided individual guidance to students.

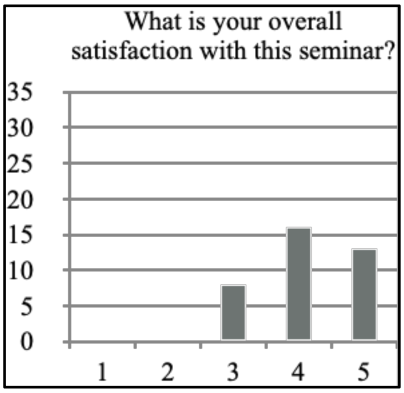
WordPress is very often used for web page creation, is often a target of hackers and had some typical vulnerabilities. It was a good foundation for learning penetration, data collection elevation to root privileges and better understanding of the criminal mindset. After the cybersecurity expert explained the task using Powerpoint slides, and a video, the regular faculty teacher moved among the students and gave individual guidance.

Example of explanatory material for *CTF (Hacking Techniques and Root Privilege Elevation)*

Another cybersecurity expert taught 5 of 15 classes on Information Security Management. The purpose of this class is to learn recommended concepts and examples of information security management in both the public and private sector, including examples from abroad, and understand implementation of security concepts as individuals. Regular faculty teachers can teach the concept of information security management in an organization, but it is difficult to discuss the information security management framework for each enterprise including case studies, threats in cyberspace, and the practice of establishing an Information Security Management System (ISMS). This cybersecurity expert's class is also highly regarded by students and will be continued next year.

Current Implementation

In July 2022, a network router penetration seminar was led by a cybersecurity professional assisted by full-time faculty. This seminar was made up of five lessons: Understanding the product and creating an attack plan, Firmware image extraction, Authentication, Password parsing, and Decoding. After the seminar, students completed a survey which yielded very positive feedback. Students found the seminar interesting and that the information is valuable. Students found the instructor to be extremely knowledgeable about the topic at hand.



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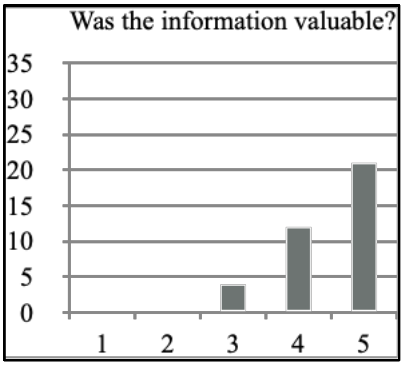

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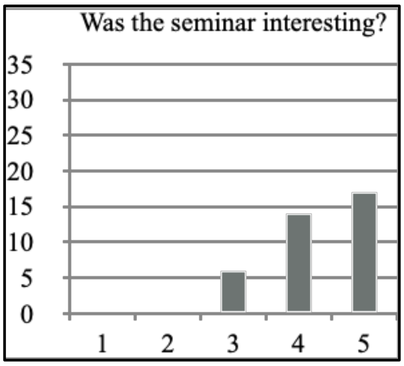

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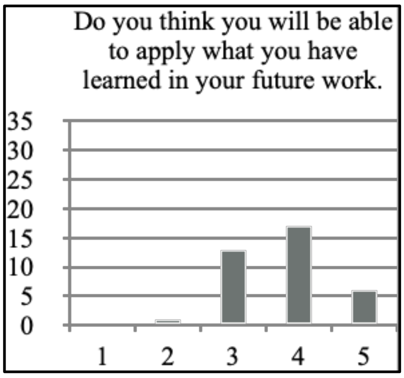

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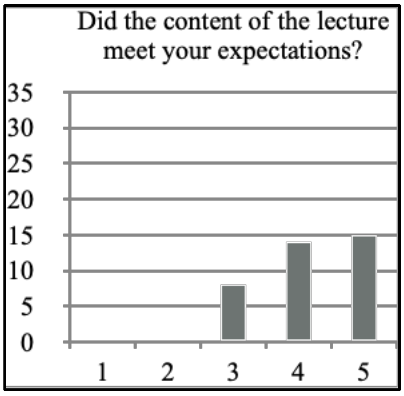

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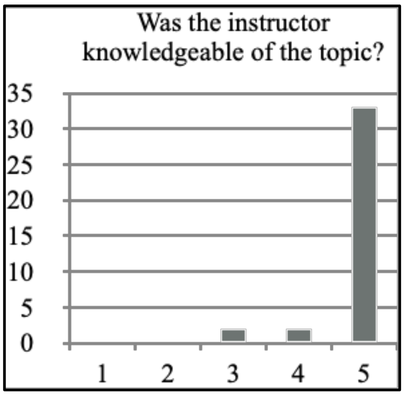

Table 6

Conclusions

The response of the students who participated was very good, and responses to the task were overwhelmingly positive. Post-task assessment showed this positive effect. It is common for teachers to explain defensive measures, but it is rare and difficult for them to demonstrate cyber-attacks and the psychology of cyber-attackers. Many students said they learned practical skill and the latest technology.

In addition to the effect of education for students, full-time faculty members were able to acquire the latest technology, which was a meaningful opportunity for the faculty group.

The difference between these classes and those taught by part-time instructors in the past is that examinations and performance evaluations of the contents of the exercises are conducted by full-time instructors who participate in the exercises together with students, and this corporate instructor can concentrate on the implementation of the exercises. In addition, it is difficult for a full-time instructor to prepare for the exercise from the perspective of an attacker.

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LEARNERS' PERCEPTION OF A CAREER CARD GAME FOR EDUCATION AND CAREER GUIDANCE

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Abstract

Technical and soft skills are essential in the working world, but learners are typically clueless about the essential skills required for the different diploma-related careers. To bridge this gap, a card game aimed to provide education and career guidance (ECG) for learners in the Diploma in Food Science & Nutrition (DFSN) was developed. The five major DFSN-related occupations in the game are: process technician, quality control/quality assurance lab technician, assistant food technologist, assistant market development executive and dietary assistant. To start the game, learners form groups of 4-5 where they will each choose an occupation card which contains the job descriptions, key tasks, technical and soft skills related to the respective occupations. The other technical, soft skills and action cards were distributed among players. Points are indicated on the various technical and soft skills cards. Points are rewarded when a technical card is placed out or when the tasks shown on the soft skills cards are completed. At the end of the game, the player who has collected the most number of relevant technical and soft skills to their occupation and therefore, with the most number of points, wins. The game enabled learners to understand the job description, technical and soft skills relating to the occupation, and this would help them to advance in understanding from an ECG perspective. A survey with a four-point Likert scale was administered at the end of the session to understand learners' perception of the game. 93% of the respondents (*N*=88) agreed that the goals and objectives of the game were clearly defined. Most of the learners (85%) enjoyed playing the game and they (81%) thought about their future profession through the game. However, the game can be improved by simplifying the points system and providing clearer instructions on the gameplay. The game can also be further modified by having two individual decks of cards, a technical and a soft skills deck which allows learners to focus on either deck when time is limited. The game is currently being expanded to other diplomas in the School of Applied Science, Nanyang Polytechnic.

Keywords: *social learning, education and career guidance, career card game, technical skills, soft skills*

Introduction

Technical and soft skills are important in the workplace, but most learners are unaware of the career options and skills required in their future professions related to their diploma of study. In Nanyang Polytechnic (NYP), learners currently obtain education and career guidance (ECG) through these main channels: (i) personal mentor (PEM), with the relevant industry experience, assigned to each class, (ii) Personal Career Strategy (PCS) sessions introducing diploma-related occupations, (iii) ECG talks, and (iv) during learner's internship, where the industry supervisor provides advice and guidance.

Such traditional learning methods, in which learners passively listen to and interpret the content delivered by the teacher, are still used in many higher education institutes because they are a convenient way to teach and introduce basic concepts (Van Eynde & Spencer, 1988; Smith & Valentine, 2012). On the other hand, learners are not engaged in the passive-learning classroom. Although several active learning activities, such as team-based learning, problem-based learning, small group discussion, and presentation, have been attempted, they have only been able to engage a small group of vocal and highly motivated learners.

Several studies have been conducted to support the efficacy of using educational card games and other constructivist approaches (Cohen et al., 1989; Lazarowitz et al., 1994; Candido, 2000; Burrowes, 2003; Marasigan, 2006; Rivera, 2006; Tuzun et al., 2009; Barclay et al., 2011). Educational games can help learners focus their attention, and improve positive peer relationships, leading to a deeper understanding of the material and developing advanced problem-solving abilities (Nemerow, 1996; Srogi and Baloche, 1997; Kumar and Lightner, 2007; Wilson et al., 2009). Despite this, to the best of our knowledge, no card games are used to provide career guidance and introduce the necessary skills for applied science jobs. To bridge this gap, a card game called MyCareers was created to provide engaging and fun ECG for learners. The game was implemented for learners in the Diploma in Food Science & Nutrition

(DFSN). Learners were exposed to the job descriptions, key tasks, technical and soft skills of five major occupations in DFSN via this game. The five major occupations are Process Technician, Quality Control (QC)/Quality Assurance (QA) Lab Technician, Assistant Food Technologist, Assistant Market Development Executive, and Dietary Assistant. Learners are exposed to and gained a better understanding of the essential skills required for DFSN-related jobs through the element of play, aiding their self-development.

The goals of this study are to determine learners' perception of the card game, including clarity of the game's objectives, enjoyment while playing the game and whether the game helped them think about their future profession, and to gather feedback on how the game can be improved further. The successful implementation of the DFSN career card game will enable the game to be adapted and expanded to the other diploma in the School of Applied Science (SAS), NYP.

Materials and Methods

Card Design

Each set of the card game contains 60 cards, which are divided into four categories: occupation cards, technical skill cards, soft skills cards, and action cards. The job descriptions, key tasks, technical and soft skills of four of the occupations, namely Process Technician, QC/QA Lab Technician, Assistant Food Technologist, and Assistant Market Development Executive, were taken from the food manufacturing skills framework (SkillsFuture Singapore, 2021). The fifth occupation, dietary assistant, is a common job for DSFN graduates. Each occupation card (See Figure 1 for example) was created to help learners gain a better understanding of potential job prospects.

Figure 1: An example of occupation cards for the job of dietary assistant, including job description, key tasks, and the soft and technical skills to be collected.

An action card (See Figure 2 for example) is indicated by a blue diamond shape at the top left corner of the card. Action cards allow players to either gain and lose points or change the gameplay through snatching, switching, keeping, and/or reversing the direction of play.

Figure 2: A reverse action card in which the direction of rotation changes when cards are played.

Technical skills are defined as a skill, expertise, or technical competence related to the workers' field, whether engineering or technical (Medina, 2010). Technical skills are frequently associated with the use of tools, equipment necessary for proper and efficient work, and all technical matters. Dietary assistants, for example, will need to collect patient information to ensure that patients are served meals that meet their nutritional needs. As a result, gathering patient information is a necessary technical skill for dietary assistants. A technical skill card (See Figure 3 for example) can be identified by a spade shape on the top left corner and the point(s) associated with it is indicated on the top right corner of the card. Players must try to obtain technical skill cards corresponding to their assigned occupation to obtain more points to win the game.

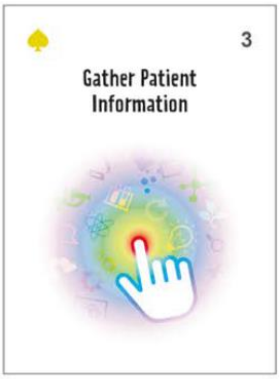

Figure 3: A technical skill card related to the occupation of a dietary assistant.

Soft skills are critical skills that enhance a person's interactions, job performance, and career prospects (Parsons, 2008). These skills are not limited to any job position or workplace environment (Zubaidah et al., 2006), but can be applicable to a wide range of jobs and tasks (Kruger, 2006). For example, teamwork is an important soft skill for a dietary assistant because he or she will need to collaborate closely with doctors, nurses, and pharmacists to provide the best care to patients. A soft skill card (See Figure 4 for example) can be

identified by a heart shape on the top left corner and the point(s) associated with it is indicated on the top right corner of the card. Players must complete the task specified on the card to obtain the card and points. If the player failed to complete the indicated task, the card is discarded into the discard pile.

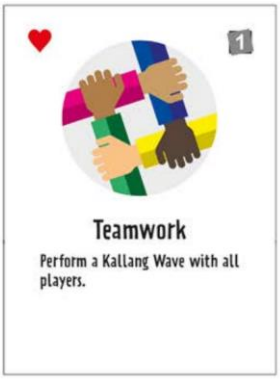

Figure 4: An example of a soft skills card where players must complete the specified task to obtain the card point(s).

Game Activity

The game was played over two one-hour sessions with their PEM. Learners were divided into groups, comprising 4-5 players. The following materials were required for the game: MyCareer playing cards, A4-size papers, pens, and mobile phones. Some soft skills tasks were performed using A4 paper and pens. Mobile phones were used to take photos to complete some soft skills tasks and participate in the online survey after the game.

Each player selects an occupation card based on their preference or by random allocation. The deck of 60 cards, containing technical skills, soft skills, and action cards, was shuffled, and distributed evenly to the players within a group. A player began the game by laying down any card on hand. To earn points indicated on a soft skill card, the player must complete the task specified on the card. For technical and action cards, the player would simply lay the card in front of them to receive the points associated with the technical skills or to enable the action on the action card to be carried out respectively. The game was played in a clockwise direction, with each player taking turns. A round is completed after all players play a card. After each round, all players must pass their remaining cards, in a clockwise direction, to the next player. The game ended when there are no more cards left on the player's hand. The players then computed the total number of points earned. They first added up all the points listed on the cards. 1 bonus point was awarded for each matching technical and soft skills indicated on their occupation cards. An additional 10 bonus points were awarded for each pair of technical skill cards, and an additional 30 bonus points were awarded if all four relevant technical cards were collected. If the players collected at least three relevant soft skills cards, they received an additional 30 points. The player with the most relevant technical and soft skills, and thus the most points, wins.

The investigator and the PEM, who conducted the game, then shared more about the various job descriptions and technical skills required for the five occupations with the class and emphasized the purpose of this card game.

Research Method

This study included DFSN learners from years 1 to 3. At the end of the two one-hour sessions, learners were asked to complete a 16-item online survey, consisting of 10 quantitative and 6 qualitative questions. The quantitative questions used a four-point Likert scale, with 1 indicating strongly disagree and 4 indicating strongly agree. During data analysis, the agree and strongly agree responses were combined into a single category called agree while the disagree and strongly disagree responses are combined into the disagree category. The survey results were used to better understand learners' perceptions of the game and to improve the card design and game mechanics.

Results and Discussion

A total of 88 responses were obtained from the participants. The card game's goals and objectives are to provide DFSN learners with a better understanding of future job options while also having fun through bonding with their classmates. According to the survey results, 93.2% of respondents agreed that the game's goals and objectives were clearly defined.

Examples of quantitative questions in the survey include 'I enjoyed playing the Card Game', 'I would recommend it to others', 'I was able to think about my future profession while playing the Card Game', and 'I liked that I could play the Card Game with people in my class'. Figure 5 shows the survey results of some of the quantitative questions.

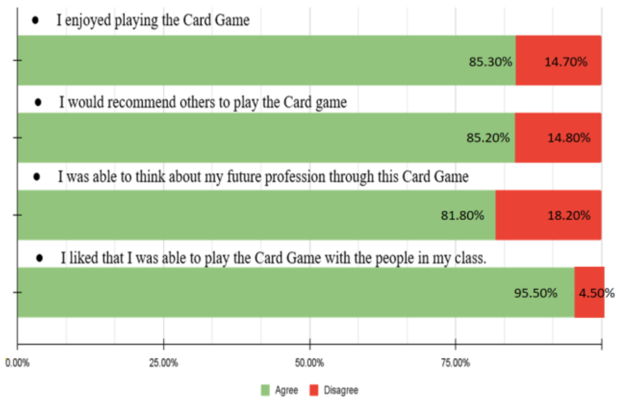

Figure 5: Percentage of respondents who agree (green) or disagree (red) on four of the quantitative questions.

The percentage of respondents who agreed with the statement 'I was able to think about my future profession

through this Card Game' was 81.8% and this showed that the goal of enhancing ECG through the card game is met. The small percentage of disagreement to the statement could be due to learners having heard of all five occupations mentioned. Learners may have been briefly introduced to the various diploma-related occupations over the years. For example, year 1 learners may be unfamiliar with these occupations, whereas year 2 and 3 learners may have heard about them through their PCS modules.

The responses revealed several common themes. These themes include the game being *fun*, *interactive* and *easy to understand*. Most learners commented that the game was fun because they enjoyed playing the game in a physical setting with their friends and the actions and tasks were creative. Joyful learning has been found to be a strategy that has a positive impact on learners (Anggoro et al., 2017). Bringing joy to learning also indirectly contributes to a human's happiness, intelligence, competence, and success (Ismanto, 2018). Learners also mentioned that the game was interactive because it forced them to get out of their comfort zones through a hands-on activity while also allowing them to get to know their classmates better. Finally, learners find the game simple to grasp because the rules are simple, the card designs are appealing, and it was simple to grasp basic concepts of the various occupations through playing the game.

88.6% of the respondents agreed that the card game is well designed. However, the game mechanism can be further improved. The most common suggestion on how to improve the card game included simplifying the point system, simplifying some of the tasks on the soft skills cards, and including an instruction card with all the rules and instructions. It was previously reported that a successful educational group game should have a simple game mechanic that combines the game and pedagogical elements to create a fun and engaging learning experience (Triboni & Weber, 2018). By considering learners' feedback, we explored ways to simplify and improve the game.

To simplify the point system which appeared to be confusing to the learners, any player who can gather all four matching technical skills cards in their respective occupation card wins the game, or if none of the players has all four matching technical skill cards, the player with the most points wins. In addition, a scorecard for each occupation will be included to aid in the point-counting process.

Learners also commented that there were too many cards with diverse actions. The game will be simplified by dividing the cards into two decks: the main deck with technical and action cards, and an extension deck with only soft skills cards. The main deck can be played without the expansion deck, allowing learners to focus solely on the technical skills required for the various jobs. This is especially useful for a quick round of the game when time is limited. The expansion deck can be used in conjunction with the main deck to teach both technical and soft skills for the five occupations in DFSN. This allows for flexibility in playing the card game depending on the objectives of the game and the time available.

Some learners also mentioned that some of the tasks in the soft skills cards were difficult to comprehend and complete. As such, the more challenging actions were replaced with simpler alternatives, and the task instructions were rephrased so that the learners could better grasp the instructions on the soft skills cards. Figure 6 depicts the changes made to some of the activities on the soft skills cards. With these improvements to be implemented, learners would be able to navigate the card game smoothly and have a better experience playing the game.

BEFORE	AFTER
Get at least 50% of the players to vote you as creative after you performed an item for 30 sec.	Get at least 50% of the players to vote you as creative after pitching your idea on selling a pen.
Get at least 50% of the players to vote as good for a service that you received or provided.	You are the cashier, choose a player to act as a customer. Get at least 50% of the players to vote your service as good.
Choose a player, sit on the floor back to back with both of your arms interlocking. Attempt to stand up while maintain the position	Describe the features of a fruit, choose a player to guess correctly. .
Get yourself go through a piece of A4 paper by tearing a hole.	Get yourself through a piece of A4 paper by folding and cutting it.
Get all players to stand on a piece of A4 paper.	Get all players to stand on a piece of A4 paper. **Hint:** There are many ways to complete this.

Figure 6: Task instructions for soft skills before and after revision.

Conclusions

Most learners (93 %) agreed that the game's goals and objectives were clearly defined. Most of the learners (85%) enjoyed playing the game, and they (81%) thought about their future profession while playing it. Learners found the game to be enjoyable and useful in learning about the various occupations in the food science and nutrition sector. After considering the responses, the card can be improved by simplifying the way to determine the winner of the game. An instruction and a scorecard will also be included so that the instructions for gameplay and calculating the points can be referred to rather than seeking guidance from the tutor.

Since the game was generally well-received by learners with plenty of positive responses, the authors planned to expand the card game to the remaining diplomas in SAS. A subsequent study on the improved card game implemented in the various diplomas will provide insights into the effectiveness of the career card game as an alternative ECG activity. Educators interested in modifying and implementing the career card game for their courses could also use the cards as a template.

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Annex

The list of questions that were asked in the google form survey was:

The quantitative questions that are asked in the survey on a four-point Likert scale are as follows:

1. The goals and objectives of the Card Game are clearly defined.

2. I would recommend others to play the Card Game.
3. I enjoyed playing the Card Game.
4. The Card Game is well designed.
5. I liked that I was able to play the Card Game with the people in my class.
6. I was able to think about my future profession through this Card Game.

Other questions include:

7. The number of cards was appropriate. Yes/No
8. If your answer is no, what would be an appropriate number of cards for the Card Game?
9. The duration required to play the Card Game is reasonable. Yes/ No
10. If your answer is no, what would be the suitable duration for the Card Game?
11. It was difficult to play the Card Game. Yes/No
12. If you think the card is difficult to play, what is the reason that the card is difficult to play.
13. Are the actions given by the cards doable? Yes/No
14. After playing the Card Game, could you name 1 career you have not heard of before?
15. What are the 3 features you like about this Card Game?
16. How can we improve the Card Game? (e.g., Mechanism, Design, Instructions, etc)

DISRUPTING THE DISCIPLINES: A PROPOSED FRAMEWORK AND TEACHING AND LEARNING ACTIVITIES FOR TRANSDISCIPLINARY PROJECTS

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Abstract

This paper proposes and tests a design-led approach for transdisciplinary projects. A 3-stage design framework (Investigate, Imagine, Implement) was adapted and a toolkit of teaching and learning (T&L) activities was curated in engagement with 29 lecturers from the Media, Arts, and Design (MAD) School. The 3-stage design framework was implemented in the Transdisciplinary Innovation Project (TIP) module. Pre- and post- surveys were used to measure the effectiveness of this design-led approach on students' perceived abilities in working in transdisciplinary teams and changes in their transdisciplinary thinking mindsets. Results support a design-led approach in transdisciplinary projects and provide evidence for the robustness of the framework and activities in promoting transdisciplinary thinking in students.

The proposed 3-stage design framework and the Transdisciplinary Toolkit of T&L activities is online at https://sites.google.com/view/madtdtoolkit/home. It is made public for educators to use and share.

Keywords: *transdisciplinary thinking, interdisciplinary learning, design innovation, design education, pedagogy*

Introduction

Disruption across disciplines and industries requires new skills to solve real-world complex issues. Identifying multiple solutions to real-world complex problems demands "thinking beyond disciplines, or connecting the dots" (Organisation for Economic Co-operation and Development (OECD), n.d.). Transdisciplinary thinking, via synthesising knowledge and insights across boundary disciplines to guide decisions and foster cooperation, has also been identified as a critical core skill under the Singapore Skills Framework (SkillsFuture SG (SSG), n.d.). It is therefore imperative that we prepare students to tackle the complex problems of their future by equipping them with abilities to work in transdisciplinary teams and to develop a transdisciplinary thinking mindset.

In this paper, a 3-stage design framework (termed as Investigate, Imagine, Implement) is proposed as a T&L process for transdisciplinary student teams to solve real-world complex problems. 29 lecturers from the School of Media, Arts and Design (MAD) were engaged in small group discussions to curate a Transdisciplinary Toolkit of T&L activities that were thought to work best in transdisciplinary projects. The 3-stage design framework was tested in the Transdisciplinary Innovation Project (TIP) module in March 2021. In this module, students work in mixed-diploma groups to tackle real-world challenges issued by industry partners (e.g., Boeing). In 10 intensive days, they conduct research to understand multiple perspectives, bring inspiration from their own diplomas to the groups, and work collectively to brainstorm, develop, and test a solution.

Students' perceived abilities in working in transdisciplinary teams and their transdisciplinary thinking mindset were measured through pre- and post-surveys. Results from both studies support a design-led approach in transdisciplinary projects and provide evidence for the robustness of the framework and activities in promoting transdisciplinary thinking in students.

What is transdisciplinary thinking?

Despite decades of cross-disciplinary practice in the universities, there is still a lack of consensus on definitions of the terms "multidisciplinary," "interdisciplinary," and "transdisciplinary" (Design Council UK, 2010). It suggests that "multidisciplinary" describes situations where several disciplines cooperate but remain unchanged. In "interdisciplinary", there is an attempt to integrate perspectives from several disciplines. On the other hand, "transdisciplinary" involves a pursuit of a fusion of disciplines underpinning an approach oriented to complexity or real-world problem-solving.

Our working definition of transdisciplinary thinking is: "solving complex problems, in a collaborative manner, by integrating knowledge, skills and abilities across disciplines" (Sim & Chong, 2020). A transdisciplinary team is one that consists of individuals from different backgrounds and disciplines (e.g., users, experts, governmental representatives) who join to work on a project or complex problem (Ausgurg, 2014; OECD, n.d.).

To work well in a transdisciplinary team, students must be able to consider the perspectives of different stakeholders (Payne & Jesiek, 2018), gain knowledge of the complex problem and connected issues (Ausgurg, 2014; Payne & Jesiek, 2018), learn from other disciplines (Mâsse et. al, 2008; Payne & Jesiek, 2018) and be able to synthesize knowledge and insights across disciplines (Gehlert, 2013; SSG, n.d).

Besides having abilities to work in transdisciplinary teams, students must embrace a transdisciplinary thinking mindset. Transdisciplinarity is needed to achieve collaboration across disciplines to achieve results beyond what one discipline could achieve alone (Thompson et. al, 2017). When students are open to "criss-cross back and forth between disciplines", new knowledge is generated beyond the usual siloes, which are key characteristics of transdisciplinary thinking (McGregor, 2004).

Why a design-led approach?

Design-led processes teach individuals to tackle challenges by empathising with the needs of the target audience, and by learning collaboratively through dynamic exchanges of ideas (Jamal et. al, 2021). There are many well-validated design processes like Design Thinking (https://designthinking.ideo.com). Design Thinking is a meta-disciplinary methodology where discipline-bound rationales are replaced with a process that forms a common basis of knowledge and agreement between disciplines (Lindberg et al., 2010).

A design-led approach fosters in-demand skill sets like creative thinking and strategic thinking (Design Education Review Committee, 2019). A design-led approach is not exclusive to designers, and non-designers benefit from learning co-creative problem-solving skills (Brown & Katz, 2011). Importantly, a design-led approach has been acknowledged by multiple authors as an effective way of facilitating the process of connecting the dots needed to understand and find solutions for real-world complex challenges (Boradkar, 2017; Bailey et. al, 2019; Payne & Jesiek, 2018).

There are three key reasons why we think a design-led approach would increase students' abilities in working in transdisciplinary teams and in fostering transdisciplinary thinking mindsets.

First, experiential learning has been identified as key to promoting transdisciplinary thinking (Gehlert, 2013; Nicolescu & Ertas, 2013), by enabling students to gain greater knowledge about the complex problem. Especially in early project phases, it is crucial for the transdisciplinary team to build a joint project vision and use experiential exercises like field immersions to discover new knowledge (Nicolescu & Ertas, 2013). A similar concept to experiential learning can be found in design-led approaches. For example, in human-centred design, it is important to have an understanding of the user and broader context as well as the ability to integrate that understanding into the design (Zoltowski, 2012).

Second, an iterative approach has been identified to promote transdisciplinary thinking where "understanding that failure and persistence... is a necessary and productive aspect of success" (Goldman, 2017; OECD, n.d.). The processes of a design-led approach require multiple short iterations and testing loops and is a core aspect of the varied design-led approaches studied across different industries and transdisciplinary projects (Gericke et al, 2013). Further, the experiences and prototype testing with real users and stakeholders in human-centred design lead to further improvements to the design via multiple iterations, e.g. by challenging the initial assumptions about the design's feasibility, (Zoltowski, 2012).

Third, transdisciplinarity requires "meaningful knowledge co-production" through bringing together individuals from different disciplines and backgrounds (Thompson et al., 2017). The design-led approach enables a transdisciplinary team to translate design observation, insights, and strategy into innovative solutions. The focus on co-creative problem-solving enables the transdisciplinary team to see possibilities leading to innovative outcomes.

With this background, two hypotheses are tested:

H1: Students will have greater perceived abilities in working in transdisciplinary teams after using a design-led approach in a transdisciplinary project

H2: Students will have a greater transdisciplinary thinking mindset after using a design-led approach in a transdisciplinary project

Developing a design framework and T&L activities for transdisciplinary projects

The design frameworks including Design Thinking (https://designthinking.ideo.com), Sprint (https://www.gv.com/sprint/), Double Diamond (https://designcouncil.org.uk/), and Critiques Pedagogy (Tovey, 2015) were reviewed. In each of these design processes, while different terms and tools are used, there are clear overlaps. Each process begins with a research and understanding phase, followed by an ideation phase, and finally a testing and iteration phase. These phases are adapted and for simplicity, have been terms as the 3-I (Investigate, Imagine, and Implement) framework.

This 3-stage design framework (Investigate, Imagine, Implement) is proposed as the T&L process for students in transdisciplinary teams to solve real-world complex problems, by conducting research to understand the problem (Investigate), ideating and developing solutions (Imagine), and testing and iterating solutions (Implement). 29 lecturers from the MAD School were engaged in small group discussions to curate T&L activities that were thought to work best in transdisciplinary projects.

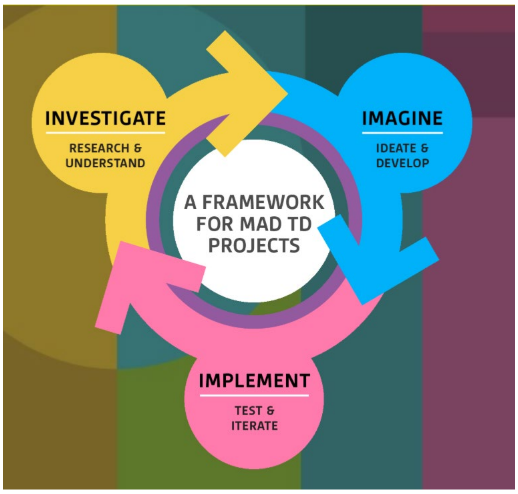

Figure 1. 3-stage design framework (Investigate, Imagine, Implement)

One nuanced difference in our 3-stage framework is the greater emphasis on the 3rd stage: Implement. This iterative stage is critical in promoting transdisciplinary thinking (Gericke et al, 2013). When students prototype, test and make refinements, they learn “failure and persistence... is a necessary and productive aspect of success” (Goldman, 2017; OECD, n.d.).

Method

The impact of a design-led approach using the 3-stage design framework (Investigate, Imagine, Implement) was tested in the TIP module in March 2021. TIP is a polytechnic-wide elective (PWE) chosen by year one to three students from all schools in Singapore Polytechnic (SP). It is taught in a block-teaching format across two weeks during the semester break.

Participants. 105 students from 25 diplomas across SP were enrolled in the TIP. Students were placed in groups of five or six and worked with industry partners on a real-world project challenge. The students’ diploma and demographics (e.g., gender, year of study) were considered in the groupings, to ensure diverse and transdisciplinary teams.

Four classes used activities developed in the GV Sprint (https://www.gv.com/sprint/) only. GV sprint is a well-used design process and set of activities developed by Google Ventures to help companies ideate and prototype ideas quickly and effectively. One class was selected to pilot additional T&L activities on top of the Sprint activities which were selected from the Transdisciplinary Toolkit (see Figure 2).

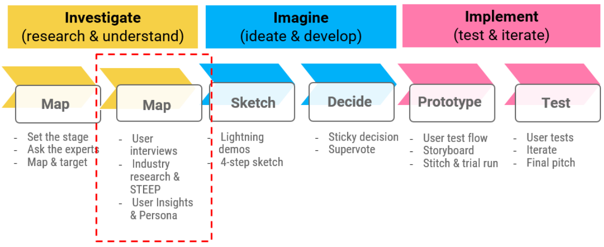

Figure 2
The GV Sprint’s and pilot’s T&L activities in the TIP Module

Of the 105 students who enrolled in the module, 98 students completed the post-programme survey (93.3% response rate). Because of misreports in IC numbers (used to match surveys while maintaining anonymity), the pre- and post- surveys from only 84 students were successfully matched (80% response rate). The demographic profile of the participants are in Table 1.

Table 1
Demographic profile of survey participants (Study 2)

School/Discipline	Year of Study
39% Engineering; 29% Media, Arts, & Design; 10% Business; 3% Architecture & Built Environment, 9% Computing, 10% Chemical & Life Sciences	27% year one; 58% year 2; 15% year 3

Student perceptions of the TIP module were very positive. 99% of students rated the TIP experience as ‘Very Good’ or ‘Good’, and 96% would recommend TIP to their SP friends.

Materials. Students completed an online pre- survey before the start of the module and a post- survey at the end. The survey consisted of scale questions to test the hypotheses, and two open-ended questions for qualitative feedback.

For *H1*, perceived abilities in working in transdisciplinary teams was measured through five 7-point likert scale questions (1 = strongly disagree; 7 = strongly agree). Students were asked to rate their level of agreement with statements that started with “When working on a real-world problem in a transdisciplinary team, I am able to… ”. The statements captured different abilities required in transdisciplinary teams, for example, the ability to consider different perspectives, and combine knowledge and skills across disciplines. As there is no accepted psychometric instrument to measure transdisciplinary abilities, these measures were adapted from previous studies on transdisciplinary groups (Mâsse et. al, (2008); Payne & Jesiek, 2018). The average pre- and post- scores were tabulated and tested using paired sample t-tests.

For *H2*, transdisciplinary thinking mindset was measured using scenario questions (adapted from Payne & Jesiek, 2018). In the scenario questions, students were asked to imagine that they were tasked with a real-

world complex problem and to select what information or resources they would need to tackle the problem. The options given consisted of six discipline-related options (e.g, knowledge and skills in media and design) and six non-discipline-related resources (e.g., budget).

To measure their transdisciplinary thinking mindset, the number of discipline-related options excluding the student's own discipline was tabulated. For example, a media and design student who selected knowledge and skills in engineering and business would be given a score of 2, while an engineering student who selected the same options would be given a score of 1. A higher score indicates a greater transdisciplinary thinking mindset as respondents show implicit openness to tapping on the resources of disciplines outside of their own. The scale ranges from 0 (selected no disciplines outside one's own) to 5 (selected all 5 disciplines outside one's own). The average number of disciplines and non-discipline related options were tabulated in the pre- and post- surveys and tested using paired sample t-tests.

Results and Discussion

H1: Perceived abilities in transdisciplinary thinking

Table 2 provides the pre- and post- descriptive statistics and the paired-sample t-tests on the likert scale statements.

Table 2
Pre- and Post- descriptive statistics and t-tests on perceived abilities in transdisciplinary thinking

	Pre		Post		
	M	*SD*	*M*	*SD*	*t*-test
When working on a real-world problem in a transdisciplinary team, I am able to…					
Incorporate information from multiple stakeholders[a]	5.60	1.10	6.35	.91	5.21***
Identify related environmental, social, political or economic issues[a]	5.64	1.11	6.13	1.04	2.99**
Learn new knowledge from other diplomas[a]	5.88	.92	6.37	.87	3.74***
Contribute my diploma's expertise in the process[b]	5.91	.91	6.24	1.07	2.38*
Combine perspectives, ideas or skills from different diplomas other than my own[c]	5.79	.94	6.36	.95	3.92***

$^{*}p < .05$ $^{**}p < .01$ $^{***}p < .001$
Note: [a]n = 75; [b]n = 76; [c]n = 73. Respondents rated their level of agreement to the statements on a 7-point scale (1 = strongly disagree, 7 = strongly agree). Exclude "I don't know" option.

H1 is supported. Across all the statements, respondents reported an increase in the average rating given after the TIP module ($2.38 < t < 5.$; $.05 < p < .001$). The greatest increases were observed for the statements "incorporate information from multiple stakeholders" (*M* increase of 13.4%) and "combine perspectives, ideas or skills from different diplomas other than my own" (*M* increase of 9.8%).

Additional comparisons and independent sample t-tests were conducted to test the outcomes of the pilot class and the Sprint-only classes. There were no statistically significant differences in the outcomes. This suggests that the 3-stage design framework is robust and the T&L activities within the framework can be customised to address the specific needs of the project, industry partners and students, where required.

H2: Transdisciplinary thinking mindset

Table 3 provides the pre- and post- descriptive statistics and the paired-sample t-tests on the scenario question.

Table 3
Pre- and Post- descriptive statistics and t-tests on transdisciplinary thinking mindset

	Pre		Post		
	M	*SD*	*M*	*SD*	*t*-test
Scenario 1 (NEA rising dengue cases)					
No. of discipline-related options that were selected, excluding one's own discipline	2.68	1.46	3.42	1.47	4.53***
No. of non-discipline related options that were selected	5.14	1.99	4.74	2.39	-1.48
Scenario 2 (NTUC overcrowding in stores)					
No. of discipline-related options that were selected, excluding one's own discipline	2.23	1.42	3.11	1.61	3.71***
No. of non-discipline related options that were selected	4.56	1.80	4.61	2.29	.14

$^{***}p < .001$
Note: n = 85. Respondents were given six discipline-related options (e.g., knowledge and skills in business) and six non-discipline related options (e.g, budget). They were instructed to pick as many or as few options as needed to solve the complex problem listed in the scenario. Selecting more discipline-related options excluding one's own indicates a greater transdisciplinary mindset.

H2 is supported. After the TIP module, on average, students selected more discipline-related options that were outside of their own discipline in both scenario 1 and scenario 2 (M = 3.42 and M = 3.11) compared to before the module (M = 2.68 and M = 2.23). This demonstrated a greater transdisciplinary thinking mindset after the TIP module ($t = 4.34$, $p < .001$ and $t = 3.71$, $p < .001$).

The average number of non-discipline related options selected did not see a significant increase in Study 2. This provides assurance that the increase in transdisciplinary mindset was not spurious.

Additional comparisons and independent sample t-tests tests were conducted to test the outcomes of the pilot class and the Sprint-only classes. There were no statistically significant differences in the outcomes.

H2 is further supported by the qualitative comments from the students, for instance, in one of the student's reflection report, she wrote that: "Working with others from different backgrounds and on a real life problem stimulates the experience of working with others in the workplace and different working styles…made me think about other issues that are present in Singapore but not widely known to the public." Another student indicated in the survey said that: "being grouped with people from different schools, I get to explore how different people view the same things differently."

Discussion and Conclusion

In this paper, a 3-stage design framework (Investigate, Imagine, and Implement) is proposed as a T&L process for transdisciplinary student teams to solve real-world complex problems. 29 lecturers from MAD

school were engaged in small group discussions to curate T&L activities that were thought to work best in transdisciplinary projects. This Transdisciplinary Toolkit is published online and made public for lecturers to share (see https://sites.google.com/view/madtdtoolkit/home).

The 3-stage design framework was tested in the TIP module. We found support for an increase in perceived abilities in working in transdisciplinary teams. This increase was observed in both the pilot class and the Sprint-only classes. This suggests that the 3-stage design framework is robust and the T&L activities within the framework can be customised to address the specific needs of the project, industry partners and students, where required.

We also found strong support for a positive shift in students' transdisciplinary thinking mindsets. Students exhibited greater openness to considering perspectives, knowledge, and skills from other disciplines outside their own after the TIP module. Again, this points to the robustness of the 3-stage framework and provides strong support for the effectiveness of a design-led approach in transdisciplinary projects.

This paper has contributed to the research on transdisciplinary thinking. Our work is ongoing and iterative. We hope that the evidence provided in this paper provides more confidence to customize and adapt T&L activities within the 3-stage design framework to address specific project, client or students' needs in transdisciplinary projects. In future phases, we will pilot more T&L activities within the 3-stage design framework to test the relative effectiveness of specific T&L activities in promoting transdisciplinary thinking.

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MOTIVATING GLOBALIZATION FOR STUDENTS INTRINSICALLY IN ESL/EFL USING CALL

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Abstract

Since the beginning of the COVID-19 pandemic, most countries around the world became extremely strict with their border regulations. Not only were people restricted from travel and leisure, but students planning to study abroad were stopped in their tracks. Due to these restrictions being in place for an extended period (and still quite strict in Japan), most students who wanted to study abroad lost motivation. The purpose of this study is to find ways to motivate students within everyday ESL/EFL classes to still be interested in the globalized world and want to learn more about other countries and cultures through blended learning environments. Classes for lower grade (first and second year of high school) and higher grade (second and third year of university) at technological colleges in Japan, known as KOSEN, were investigated. The ESL/EFL classes were conducted in a blended learning environment using an LMS and other computer-assisted language learning classrooms with face-to-face lessons. The lessons and textbook content covered many global issues that students were not necessarily familiar with, including those related to the sustainable development goals (SDGs) created by the United Nations (UN) that students will be tasked with working to resolve when they graduate. Lower grade students were tasked with in-class and online discussion on how to recognize their place as global citizens and have some sort of motivation for changing the world, ending with a group presentation project. Higher grade students were tasked with weekly opinion essays on various SDG-related topics, which were consolidated into one final presentation task in which they were to create a political platform and run for the position of next Prime Minister of Japan based on their rural, national, and international SDG-specified platform. Detailed student feedback was obtained anonymously with every midterm test (four times a year) and then additionally at the end of the school year with an online poll. The findings of these polls and potential improvements will be discussed in detail.

Keywords: *language education, student motivation, blended learning, computer assisted language learning (CALL), English as a second/foreign language (ESL/EFL)*

Introduction

Since before the COVID-19 pandemic began, students in Japan were greatly interested in studying overseas in preparation for the Tokyo 2020 games. Many programs, such as the Leap For Tomorrow (Tobitate!) study abroad initiative (MEXT, 2020) which started as early as 2014, were put into place, and things were looking toward being a much more internationally understanding, and globalized Japan.

Unfortunately, since the pandemic began, and severe border restrictions were put in place, many students who had planned for studying abroad in the 2020 academic year (which starts in April in Japan) had all their expectations and plans turn to dust just weeks before their departures. At the time, with very little sign of things going back to normal any time soon, the thought, desires, and even concept of going to study abroad were shot down from all sides and a positive outlook towards even delayed participation in any such program were dashed.

However, knowing that one day things would ‘go back to normal’, even be it a ‘new normal’, many educators, especially those involved in study abroad programs, were always looking for any hint of being able to resume scheduled programming even amid a global pandemic. With each country having their own border restrictions, vaccination regulations, and required paperwork and what not, keeping students interested and intrigued with studying abroad was a key effort for them.

The students observed in the study were from a rural National Institute of Technology, also known as Kosen, who had previously multiple opportunities for studying abroad before the pandemic, and being thrust into online learning with little to no background or even time to prepare for the new school year, also tried to remind students of the potential light at the end of the tunnel by using information and communication technology (ICT) to help remind and motivate the students of the great big world that still awaits them despite being told to stay home from the government to prevent COVID infection.

Methods and Pedagogy

Once online learning was confirmed to be taking place, teachers struggled to be able to keep up with the times and the technology, especially veteran teachers who were strictly used to using chalk on a blackboard at all times during their lessons. However, with the help of a standardized learning management system (LMS) in the forms of Moodle and Microsoft Teams (as Kosen colleges all have licensed with Office 365) the potential for a deep, blended and fully online educational instruction was possible, even if it came at the cost of a strict learning curve for both sides.

Over a short time span of approximately a month, students and staff became habitutated to the new online learning movement, and were able to conduct lessons via YouTube streams from cameras and microphones strategically placed in empty classrooms. However, the true potential of online and blended learning was only able to be investigated with teachers that had a true interest in fully exploring the potentials of computer assisted learning, especially for those in foreign languages (also known as CALL).

Within a few months, the Kosen in question returned to in-person lessons much quicker than most other educational institutions, with very strict distancing, ventilation, and disinfection procedures to maintain the safety and peace of mind of all involved. Unfortunately, with the return on in-person lessons, most teachers returned to teaching as they had for years regardless of already having begun to experience the unique benefits of information technology for educational purposes.

This is where the uniqueness of language learning became a benefit. By using the previously mentioned YouTube streams and pre-recorded ('on demand') lessons, the instructor was able to record fully English only lessons, whereas traditionally lessons would include some explanation of key points in Japanese to ensure understanding. Students were now immersed in another language and were able to use unique features available to them, such as automatic transcribing of the speech in YouTube videos if they cannot properly comprehend with their listening skills, or even being able to slow down or replay certain points of the lessons to their hearts content.

Another key feature was the ability to share the literal views of the rest of the world using already existing online content from several sources, including YouTube. If the textbook mentioned travelling to a certain location, students were able to easily click on a link provided or search themselves for matching content related to the lessons covered. This led students to begin to spend more time looking for interesting videos or looking up more detailed information on what was covered in class if they are already online to watch and take part in the lesson itself. A key point is to keep the students interested when they are online, and not have their attention and efforts drift off to something else, which can easily happen to teenaged students when using devices.

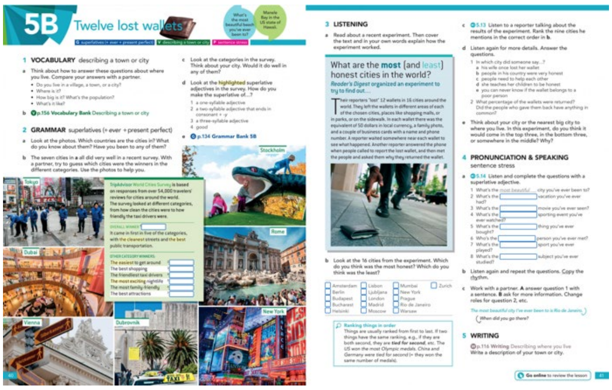

Figure 1, An example of a lesson from *American English File 3rd Edition* by Oxford University Press in which students were able to learn about various cities and their sightseeing points from still images in the textbook

Figure 2, Students were then able to increase their vocabulary through the textbook content which related to the sightseeing theme (for this particular lesson)

Also, thanks to the implementation of the Microsoft Teams LMS, students were also able to submit their homework online through PDF and Word document formats, which increased the opportunity and potential of writing activities, which most foreign language teachers dread because of the amount of time necessary to properly evaluate, and correct using traditional paper methods. With the opportunity to write digital media, corrections are also easily recognizable and just as easy to fix with the click of a button by students before even sending it in as homework. However, there is always a suspicion of dependency on online translation options, such as Google Translate and not simply relying on skill.

Figure 3, A unit of ‘Practical English’ based on potential issues students could experience at a hotel overseas taken from *American English File 3rd Edition* by Oxford University Press (2019).

Results and Discussion

Surveys of student opinions on the use of CALL and their perceptions of wanting to study abroad were obtained from all students periodically with their midterms and finals, approximately every two months. These were gathered and analyzed, and random interviews were also made with students based on specific comments which stood out, such as if needed further explanation or points of interest. Some students throughout these efforts came for advice to the teachers involved for one-on-one guidance and choosing which country and what schools to potentially go study abroad at individually and not through the Kosen-related existing programs.

One common benefit mentioned by students in their feedback was the unique perspective of not learning language through simply grammar, vocabulary and other traditional methods, but by learning about a multitude of topics that just happened to be in English, a foreign language to the Japanese-native students. In a sense, they were tricked to learning English by being taught about various topics that changed every week, almost ensuring that one week would have content that catered to the interest and intrigue of any given student's hobbies.

Because one week of content would strike their core interest and not be forced to do grammatical and vocabulary drills as often seen in traditional Japanese teaching methods, students were able to think about their interest from an international or English-speaking based audience perspective, and thus link them to wanting to learn more about how their interests were seen from around the world from various English speakers, native or not.

For example, one student that was not interested in English who was obsessed with soccer became interested in learning Spanish and wanting to do a soccer study abroad program in Spain based off one lesson which spoke about the city of Valencia and its city and people.

Conclusions

By using the strengths of online education and switching to a heavily media-based and technology-friendly teaching method, students were able to maintain and even intrinsically grow interested in studying abroad, regardless of the state of the world being in a global pandemic. Efforts are currently being made to re-enact previous student exchange and study abroad programs, starting with a two-week program in New Zealand, known for their strict contact tracing and border policies throughout the pandemic.

A previous study on ethnographic approaches to studying abroad by Ziemba (2016) mentioned the importance of pre-departure orientation sessions, on-site regular feedback and guidance, and a post-return reflection period for study abroad programs. Another study by Honda, Karube and Ziemba (2015) discussed the benefits and international exchange, and unique potentials for students from abroad at Kosen colleges. It must always be kept in mind that study abroad and student exchange programs are not solely based on Japanese students going outbound, but also inbound exchange with overseas students as well.

Given that students in Kosen colleges have not been exposed to any overseas interaction for years now, it is also essential to keep in consideration risk management in relation to potential health issues, including infection, throughout the process. However, given that there is a base format already established, adding and editing the existing handbook to meet modern day standards, including regular updates to keep up with any change in the global standards, regardless of the state of the pandemic.

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ON TEACHING PROGRAMMING TO NON-IT STUDENTS THROUGH A METHOD CAPABLE OF CONDUCTING REMOTELY BY JUPYTER NOTEBOOK

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Abstract

In recent years, two remarkable events strongly motivate us to drastically improve the educational system to make students competent in industries in the next eras. First, the use of AI and IoT has been spreading rapidly in engineering and society as a whole. Second, the COVID-19 pandemic demands society to put their work online, including teaching activities conducted in schools. It seems difficult to satisfy both demands while providing high-quality education. This is because, while student experiments are important in KOSEN education, where students can learn more deeply by working with their own hands and handling real objects, in remote classes, students are not involved in the experience, so they tend to stay passively.

Under these circumstances, we developed a new method of giving students experiment classes focusing on developing their competence in programming skills needed as mechanical and electrical engineers. It pays particular attention to the following points: First, students often have little prior knowledge of IT and tend to be afraid of coding, so themes are chosen to be familiar with them as much as possible to feel comfortable during the classes. Second, by conducting actual classes on the Jupyter Notebook deployed on a cloud server, students can access it from their homes, enabling us to easily go online whenever necessary and have natural two-way interactions between lecturer and them.

Using this method, the author conducted a graduation thesis session at the Department of electronic and mechanical engineering, Yuge College, National Institute of Technology. Students developed simulations of basic mechanics, and they discovered, remarkably, on their own, a famous criterion for numerical simulations. This method thus can be an effective way for students in mechanical engineering to learn coding.

Keywords: *Teaching Methods, Online Learning, Education in Mechanical Engineering, Jupyter Notebook, Numerical Simulation*

Introduction

KOSEN has long been giving education to students in the engineering field, and those who graduate have played important roles in many parts of the Japanese industry. Yuge College's Department of Electronics and Mechanical Engineering also offers a curriculum that lets students acquire basic mechanical and electronic engineering skills. As IoT and AI technologies have become more prevalent in society in recent years, there is an increasing demand that mechanical engineers also have a certain degree of knowledge of information technology. For this reason, our department has recently been giving practice on, for example, microcontrollers using Arduino as a material due to its usefulness for educational purposes (e.g., Galadima, 2014).

However, there are several obstacles to this given students' standpoint. One is that many mechanical engineering students lack basic knowledge of informational systems. One reason for this is that the department's objective is to train mechanical engineering engineers, and the five-year curriculum is designed to emphasize subjects in line with such an objective. Another problem is that they are at most not good at and, in some cases, do not even have prior experience in programming, making it difficult for them to be motivated to learn. To solve the problems, it is necessary to motivate them for their efficient learning, for example, by brushing up on teaching methods.

In addition, due to the COVID-19 epidemic that has raged recently, more and more people in all parts of society, including businesses and schools, turn to work remotely from their offices. Our school is no exception and was forced to close in the first half of 2020, during which all classes, including workshops and experiments, were conducted online. Given that similar situations may occur in the near future, adopting a different teaching method would be important to avoid risks in the coming days. While it is difficult to conduct workshops and experiments in mechanical engineering via remote sessions because the students need to handle the experimental equipment with their own hands, teaching information engineering can overcome these restrictions. Therefore, we took advantage of this opportunity to

create an infrastructure that allows our mechanical engineering students to learn programming even in remote lectures easily, and use it for their graduation research.

We adopted the new method to teach programming during graduation research. By providing students with efficient assistance in learning to code, we prepared them to proceed with their graduation research on their own.

This paper is structured as follows. First, the materials used in this study are described. Next, the details of the learning infrastructure implemented in this study and the methodology of how it was utilized in practice are described. The response of how our students are accustomed is reviewed, and finally, the conclusion of this study is discussed.

Materials and Methods

In science and engineering fields, not limited to mechanical engineering, programming skill is mainly required for data processing and numerical computation. Fortran has long been a programming language specialized for numerical calculations and is still widely used in various fields. On the other hand, languages that are easier for beginners, such as Python, are widely used today. One of the features of these languages is that a wide range of frameworks and libraries can be consolidated in codes to provide various functions with relatively low learning costs while keeping code clarity. One of the famous examples is Keras/TensorFlow and PyTorch, which are widely used in machine learning as de-facto libraries. Low-level languages, which means that the language in which abstraction of data structures and algorithms are not intensively implemented, such as Fortran, are difficult for beginners to learn. Understanding how computers execute programms before learning such low-level languages is desirable. However, it is not probable that non-IT students have such a prerequisite knowledge. For such students, programming education using a language such as Python is preferable to ease their learning(e.g., Guo, 2013).

One point at which programming beginners may find it difficult is how to set up the environment. Especially in the case of Python, it is common to encapsulate the entire components within a virtual environment, such as venv, to take full advantage of combining various frameworks and libraries without being annoyed by cluttered version dependencies. However, such advanced features are difficult for beginners to use. In addition, in the learning environment envisioned in this study, students perform programming assignments on their PCs through remote lectures, so it is preferred to avoid setting up these environments on their PCs as much as possible for their ease of use. Therefore, in this study, Jupyter Notebook environments are deployed on the cloud server and made available to students via web access to easily start programming without having to prepare the environment by themselves.

Jupyter Notebook (confer reference) is an integrated development environment that allows the writing and execution of various programming languages in a Web browser. The software is built on a cloud hosting server, and users can access it over the Internet to use the Python execution environment without any prior preparation.

Because this integrated development environment has an interactive shell, users can immediately execute even a single line of code and see the results, unlike languages such as C or Java, which require compilation before each execution. Then, by observing the execution results, the developer, in this case, students, can think about what to do next and try their ideas. These features strongly support executing the many trial-and-error operations necessary for beginners to understand how codes work.

In addition, since Jupyter Notebook was originally intended to be used for intensive data handling such as statistical analysis and machine learning, it is designed so that functions such as data visualization are easy to be used and well-integrated within the execution flow. Visualizing what is going on under the hood is quite important for elementary users to understand programming well. In this sense, this development environment is considered suitable for supporting students' programming learning.

Amazon Web Service (AWS), a cloud web service, was used to deploy the Jupyter Notebook. Using a cloud hosting service eliminates the need for teachers to manage physical machines instead of having to prepare their servers and allows other lecturers to easily provide an execution environment for their classes by saving the built environment as an image file. Since this framework is supposed to be deployed on a web browser that is open to the Internet, appropriate security settings must be configured. In this study, only password protection was used to make it easier for students to access. However, more secure methods such as utilizing public key encryption should be used under the appropriate instruction beforehand. An overview of the use cases envisioned in this study is shown in Figure.1.

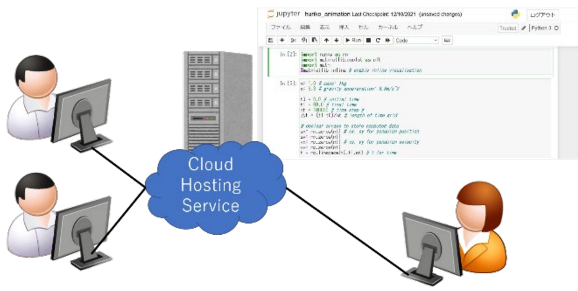

Fig.1 Schematic diagram of how the lecture is conducted. The teacher (rhs) deploy Jupyter Notebook on cloud hosting service and students (lhs) access it through the Internet.

Results and Discussion

We employed the method described in the previous section in the graduate research program in our department. The target students were five fifth-year students of the Department of Electronics and Mechanics, Yuge College. The students were tasked with solving ordinal and partial differential equations related to physical subjects familiar with their daily lives using the well-known finite difference method(FDM). FDM is a numerical method that approximates the derivative,

$$\left.\frac{\partial f}{\partial x}\right|_x, \quad \left.\frac{\partial^2 f}{\partial x^2}\right|_x, \tag{1}$$

by finite differences,

$$\frac{\Delta f(i+1) - \Delta f(i)}{\Delta x}, \quad \frac{\Delta f(i+1) - \Delta f(i-1) + 2\Delta f(i)}{\Delta x^2}. \tag{2}$$

This method is considered suitable as a subject for learning numerical computation because the method is relatively intuitive among the many numerical methods for solving differential equations.

Five students were divided into two groups of two and three. They were asked to choose what kind of physical motion they would like to calculate numerically while showing some educational movies on physics experiments: one group chose "chaotic behavior of a two-dimensional pendulum moving under the influence of a magnet," and the other "the waves hitting the coastline near our school."

A two-dimensional pendulum in motion while receiving attractive forces from three or more magnets exhibits chaotic behavior so that even slight differences in initial conditions or numerical parameters can significantly change the results of numerical calculations. Therefore, this problem is suitable for students to learn what points to pay attention to when performing numerical calculations. In addition, the school is located near the coast and has a beach with a characteristic shoreline shape. Waves crashing on this beach are familiar to students, and working out over them can motivate them to engage in learning.

The following equation describes the motion of a two-dimensional pendulum

$$m\frac{d^2\boldsymbol{r}}{dt^2} = -mg\sin\theta + \boldsymbol{F}_{\mathrm{mag}}\,. \tag{3}$$

where m is the mass of the weight, $\boldsymbol{r}$ is a two-dimensional vector representing the position of the weight, $\theta = \arcsin|\boldsymbol{r}|/l$ is an azimuthal angle of the pendulum, l is an arm length of the pendulum, and $\boldsymbol{F}_{\mathrm{mag}}$ is the magnetic force expressed by the following equation,

$$\boldsymbol{F}_{\mathrm{mag}}(\boldsymbol{r}) = \frac{\mu_0 m_0 m_i}{4\pi}\sum_{i=1}^{3}\frac{\boldsymbol{r}-\boldsymbol{R}_i}{|\boldsymbol{r}-\boldsymbol{R}_i|^3}. \tag{4}$$

where $\boldsymbol{R}_{\mathrm{i}}$ is a two-dimensional coordinate of the three magnets that are fixed on the coordinate, which exerts an attractive force upon the pendulum, and m_0, m_i are the magnetic charge of the pendulum and fixed magnets, respectively.

The students then were instructed to find the equation to be computed by Python programs by converting the derivatives in the equation of motion to finite differences based on the relation between Eq.(1,2). They were then instructed to write Python code to solve it. Because the students' programming abilities varied greatly from person to person, the instructor closely monitored their progress during this process and intervened if they could not proceed on their own. If the task is to be done over a remote session, it may be possible to check the students' progress using the web chat application screen-sharing function.

Once the code is completed, we instructed them to perform the calculations using the appropriate initial conditions and numerical parameters and visualize the results using the Jupyter Notebook functionality. Figure 2 shows how this was done. The code itself and the visualized calculation results are displayed side by the side, so there is no need to use external visualization

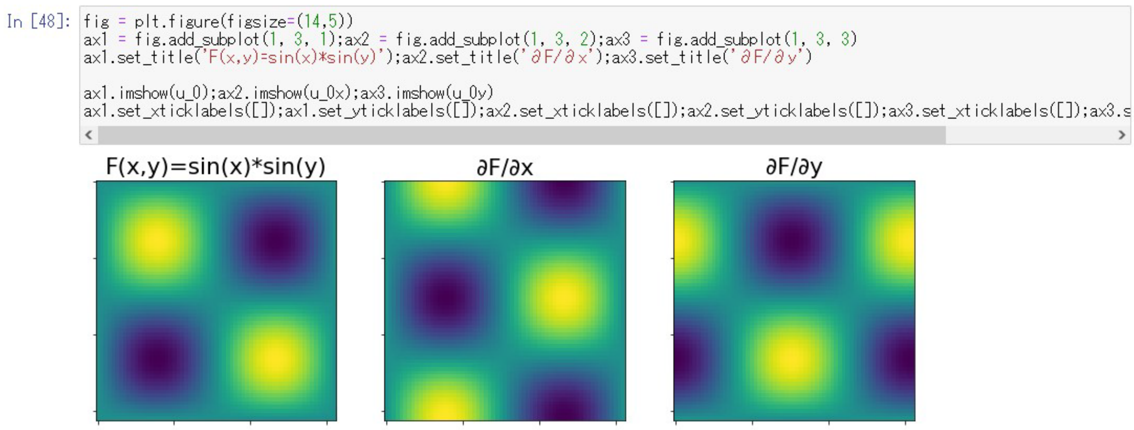

Fig.2 An example of figures, created by our students, comparing the arrays to check whether their implementation of partial differentiation is correct. As the visualization window is conjunct with the codes, one can instantly check the results, correct their codes, and execute it via interactive shell.

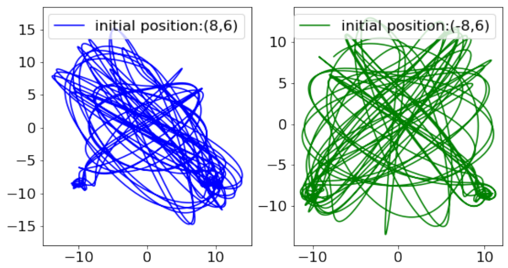

Fig.3 An example of figures, created by our students, showing the computed motion of magnetic pendulum. Two of them differs only in the initial position, but the results are significantly different due to numerical error.

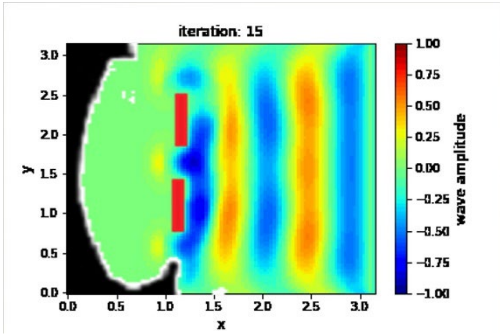

Fig.4. Snapshot of the animation gif created by our students. Python's rich visualization library enables beginners to create such a image easily.

software. For mechanical engineering students unfamiliar with various software, Jupyter Notebook makes it easy for them to view and understand the results of their own calculations.

An important numerical parameter when solving differential equations by the finite difference method is the CFL number given by the equation below(c.f. Wendt, 2008):

$$\mathrm{CFL} = \mathrm{v}\Delta\mathrm{t}/\Delta\mathrm{x} \tag{5}$$

where v is the speed of moving stuff, and Δx and Δt are the width of finite difference of space and time, respectively. If the CFL number exceeds 1, numerical calculations become unstable and diverge, or output results that are completely different from the real solution.

In this case, the importance of the CFL number in numerical calculations was not taught to the students. However, the students conducted a parameter survey of the numerical calculations and discovered that the results of the numerical calculations changed significantly when the time increments were larger than a certain value. Thus, the use of the Jupyter Notebook facilitated the visualization of the calculation results, and as a result, even students with little prior programming knowledge were able to discover important parameters in the numerical calculations on their own. One of the results comparing the two cases, the result of which should be symmetrical, are showin in Fig.3 and the difference between them excibit decayed precission due to high CFL number.

Another group used numerical calculations to determine the waves lapping on the shore. This time, the following general wave equation (6) was assumed.

$$\frac{\partial^2 A}{\partial t^2} - c^2 \frac{\partial^2 A}{\partial x^2} = 0 \tag{6}$$

As in the case of the two-dimensional pendulum, students were asked to solve the task of converting the partial differential equation into a difference equation. In order to check if the equation for differentiating the spatial derivative was correct, we had the students check it themselves using the visualization routines in Jupyter Notebook, as shown in Figure.2. As mentioned earlier, Jupyter Notebook is an interactive development environment, so students can check what is wrong with the code they have written and immediately run the corrected version to check the result again. Trying out many try-and-errors is an effective way to learn to code. In addition, mechanical engineering students, like those in our department, should have had much experience with hands-on training in their curriculum, so they are better suited to learn by doing things on their own rather than just learning theory in a classroom. We think using Jupyter Notebook is an effective way for these students to learn programming.

Conclusions

In this study, we developed a programming method that is effective for non-IT students and can be easily adapted to remote lectures. Jupyter Notebook, an interactive environment for easy data visualization, was used as the code execution environment. This execution environment can be built on Amazon Web Service (AWS), a cloud service, and with appropriate security settings, students can use it from home, thus enabling remote lectures.

In this case study, we emphasized two advantages of the Jupyter Notebook: data visualization is easy, and the interactive environment allows for easy trial and error. By utilizing this method, the students were able to learn to program efficiently and, in particular, to discover for themselves what they needed to pay attention to in their numerical calculations.

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ACTIVE LEARNING BASED ON TOURISM AND CULTURE: Lake Towada as Teaching Material [Times New Roman-12-bold/Caps]

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Abstract

Kosen students in general need a wide of variety of cultural experiences or knowledge. In the fifth year students at Hachinohe Kosen, the attempt of applying tourism for the improvement of students' cultural knowledge had been given. This attempt had been incessantly held since the subject was opened to students in 2013. Along with traditional lecture styles, but presentations and group works had been incorporated. Although many cultural subjects, including World Heritage Sites, have been treated as materials, the local tourist sites are less frequently discussed. Furthermore, not a few students are less interested in local subjects.

Lake Towada, which is located in the southern part of Aomori Prefecture, has been one of the centers of tourist attractions in Tohoku. It was designated as a national park in 1936 along with other famous tourist sites. There are many mythic legends about the origin of the lake, which probably reflects the natural history of the formation of the lake. It had been the center of religion of the areas. In addition to these traditions, many writers have written articles or information on the lake, which have been the materials for local tourism. So this lake and its history of tourism can include various aspects of cultural studies; legends, geography, history, travel writings, and so on. This can be a subject for students to develop their skills of cultural understanding.

Through this presentation it will be demonstrated that the students' cultural ideas will be bettered and contents tourism will be effective material for Kosen students' cultural understanding with reference to the active learnings concerning Lake Towada and its surroundings.

Keywords: *Active learning, tourism, local subjects, Lake Towada, travel writing, teaching material, cultural understanding*

Introduction

The main purpose of this study is to produce the new learning program based on tourism for students to study various cultural subjects. Lake Towada, which is located in the southern part of Aomori prefecture, is one of the most tourist-attracting sites in the Tohoku Areas in Japan.

Although most students of NIT, Hachinohe College are from Aomori Prefecture and they may have visited the Lake several times, it is outstanding that not so many students are familiar with the information about the lake, including the geographical data, histories of visitors, the development of transportations, and what the lake has been regarded as from the earliest time by visitors from various backgrounds including foreigners. It might be needless to discuss the importance of knowing the natural and cultural resource of one's own home country since it is useful for us to have a sense of nationality but also to build the base for understanding the similar properties of other areas. To make it short, can learning about Lake Towada lead us to build the basement for cultural understanding.

Kosen students, including Hachinohe College students, are required to work globally after their graduation. So it might be of importance for them to have a chance of training their cultural senses

Materials and/or Methods and/or Pedagogy

It has been made clear from my previous research that tourism can be an effective medium for combining the cultural material and stimulating students' motivation to solve their negative attitudes toward the knowledge of history, literature, language, sociology, or other fields of studies. At National Institute of Technology, Hachinohe College, the subject 'Tourism and Culture' (TC) has been opened to the 5th year students as one of the selective subjects since 2013 by the author (except 2014 and 2015), 2016, 2017, 2018, and 2019. Since it started in 2013, 'Tourism and Culture' has been working on lectures on histories of tourism, tourist sites, tourism resources. In 2018, in addition to the other subjects, travel writing was more focused than previous years. Through these activities, the students are expected to not only come to know about historical situations in the time

of the beginning of Meiji period but also try to think about inbound tourism through the text.

Through these attempts various significant results and effects have been clarified. However, it is difficult to say that the local tourist attractions have been focused and examined fully while some places are picked up as topics for discussion. In order to gain deeper knowledge about the history of the prefecture of Aomori, it is necessary to understand the history, background, and information related to the lake since the history of the lake is related to that of Aomori Prefecture to a large extent. In addition to the merit of its enabling students to learn geography, history, and literature not separately but as a cultural matrix, the learning of the lake can be a material for regional and global cultural understanding.

Will the students' cultural ideas will be bettered and reginal tourism will be effective material for Kosen students' cultural understanding with reference to the active learnings concerning Lake Towada and its surroundings? In this paper, these topics will be discussed in reference to the introduction of the class, and the responses of students by questionnaires..

Results and Discussion

The class has more than ninety students, so its class size is difficult for active learning but in one activity students are divided into 24 groups for making presentations on the tourism plans about Lake Towada for students from various backgrounds. Students are required to give papers in advance concerning their own ideas about the plan. In each group, most of which is made up of 5 students, members discussed their ideas and use each elements for making their group plans for presentations. Although discussions were made in Japanese, presentations were given all in English.

Figure 1. Presentations on the plan

In other assignments, students are required to choose one of the travel writings concerning Lake Towada, explore the historical background of the text, and pick up the description of the local areas as the local promotion.

Through these activities, students are expected to learn the information of Lake Towada in addition to cultures. In order to examine the students' consciousness, the following questionnaire will be given concerning the ideas on culture, history, geography, and so on.

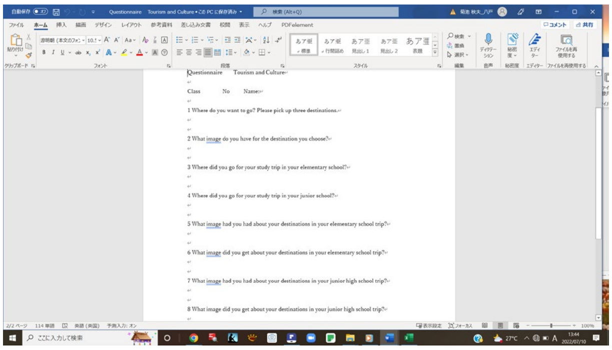

Figure 2 The questionnaire on the students' attitude toward culture understanding

The result of this questionnaire will be introduced in the presentation.

Conclusions

The research will show how much the learning abou the cultural background of local areas can be effective as the teaching material for cultural understanding, especially focusing on Lake Towada, by evaluating the change of students' motivation for learning cultures in 2022 class of Tourism and Culture. Through the activities concerning the tourism about Lake Towada, students have been working on the relationship between regions and culture. The process will enalbe studentst to get more confident in their own learning of not only local areas but also global places.

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Enhance Learners' Motivation in Learning Circuit Testing Anytime & Anywhere using 'NI-myDAQ Student Data Acquisition Device'

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Abstract

Aircraft Electrical Systems module is offered to Year-2 learners in Diploma of Aerospace Systems & Management in School of Engineering. Mini projects are integrated in laboratory activities and conducted through laboratory lessons. Every laboratory lesson is structured according to module delivery plan as 2 hours per week and learners are given 5 weeks to complete all required tasks. Some learners found it challenging to complete the tasks during the 5-week period, especially when they encountered circuit connection problems and needed more time for testing using multimeter and oscilloscope. They become demotivated in learning when they cannot continue the circuit testing anytime & anywhere even if they are free after the scheduled laboratory lesson. As a result, learners are not motivated to complete all tasks and performed poorly in laboratory assessment. A research study is setup to use NI-myDAQ Data Acquisition Device to allow learners to continue circuit testing anytime & anywhere to enhance their motivation in learning. Full autonomy is given to learners to decide if they would like to use the Device after the scheduled laboratory lesson. Sixteen learners opted for it and another group of sixteen learners who opted out were selected for comparison. These two groups of learners have a similar profile, so effect of extraneous variable and threats to internal validity are minimized. A set of survey items modified from the Intrinsic Motivation Inventory was used to measure learners' motivation on five subscales: Interest/Enjoyment, Perceived Competence, Effort/Importance, Value/Usefulness and Pressure/Tension. The effect size of each 5 subscales was computed based on Cohen's d criteria. Interviews are conducted with two group of learners to gather qualitative data about their learning experience. All results revealed that learners who used the Device for circuit testing after the scheduled laboratory lessons experienced less pressure when they came back for lessons in class; hence they enjoyed more during lessons and were more motivated to learn. With encouraging results from this small-scale investigation, lecturers are encouraged to use NI-myDAQ Device to support circuit testing anytime & anywhere, as this method provides the needed flexibility in learning while enhancing learners' engagement and motivation.

Keywords: *Motivation in Learning, Flexibility in learning, Testing Anytime & Anywhere, Scheduled Laboratory Lesson, Intrinsic Motivation Inventory*

Introduction

In the School of Engineering (SEG) at Nanyang Polytechnic Singapore, Aircraft Electrical Systems (AES) module is offered to Year-2 learners in Diploma of Aerospace Systems & Management (DASM). DASM learners learn the theoretical concepts and hands-on laboratory skills of the aircraft electrical systems through lecture, tutorial and laboratory scheduled lessons weekly. Mini projects are integrated into the laboratory activities and conducted through laboratory lessons. Every laboratory lesson is structured according to module delivery plan as 2 hours per week and learners are given 5 weeks for each project to complete all the required tasks. The AES module delivery plan is summarised in Table 1.

Table 1. Module Delivery Plan for Mini-Project

Aircraft Electrical Systems (AES) Mini Projects (2 hours per week over 10 weeks)	
Week 3 to week 7	Mini Project 1 (1 hour briefing to learners): • Introduction to Aircraft Lighting Control Circuit • Familiarization with circuit implementation, circuit testing and circuit troubleshooting procedures • Introduction of NI-myDAQ Data Acquisition Device for circuit testing Individual tasks (9 hours): • Connect circuit on electronic circuit board • Perform functional tests • Measure electrical signals using multimeter and oscilloscope or my-DAQ device * • Troubleshoot circuit if necessary
Week 11 to week 15	Mini Project 2 (1 hour briefing to learners): • Introduction to Turbine-Engine Starting & Auto-Ignition Circuits • Familiarization with circuit implementation, circuit testing and circuit troubleshooting procedures Individual tasks (9 hours): • Connect circuit on electronic circuit board • Perform functional tests • Measure electrical signals using multimeter and oscilloscope or my-DAQ device * • Troubleshoot circuit if necessary

* Optional – continue circuit testing and troubleshooting after scheduled laboratory lesson if necessary

The projects are designed for the learners to get familiarise with the Aircraft Electronic components (such as relay, switches, motor and etc.), Aircraft Electrical System related control circuits (such as Aircraft Lighting Control and Turbine-Engine Starting & Auto-Ignition Circuits), the circuit connections, the circuit testing and troubleshooting skills. They are guided to prepare component layout diagram and connect the circuit on the electronic circuit board (Figure 1). Every learner is required to understand each part of the circuits before they start to work on the circuit connections on the electronic circuit board. They are expected to perform measurements using multimeter and to capture the waveforms of electronics signals using oscilloscope from the circuit which they have constructed.

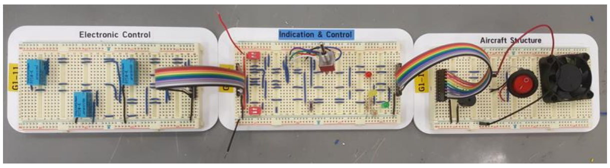

Figure 1. Turbine-Engine Starting & Auto-Ignition Circuit

The project provides a platform for the learners to understand the practical applications of the knowledge learnt about AES through first-hand experience. The learners would most likely face some challenges in troubleshooting their mistakes made along the way and will need more time for circuit testing and found it challenging to complete the tasks during the 5-week period. The adoption of the "NI-myDAQ Data Acquisition Device" in AES module aims to allow learners who need more time for learning to continue their circuit testing at the convenience of anytime & anywhere after the scheduled laboratory lesson. Learners are not only allowed to bring their electronic circuit boards out of laboratory, but also allowed to loan out the myDAQ devices to continue their works at their convenience time. Learning materials used to guide learners on circuit testing and troubleshooting can also be accessed online.

NI-myDAQ Data Acquisition Device is a portable device which interfaces to laptop and enables learners to perform measurements and capture waveforms of the electronics signals from the electrical circuit boards. In this cyclical learning process with the support of the myDAQ device, learners are provided with the needed flexibility in learning to enhance their motivation. The slow learners will have more time to do circuit testing independently at their own pace and experience possible failure. It is through the experiences of failing and troubleshooting that provide the most important learning opportunity for learners, and act as a steppingstone towards learners' success in real life. It also provides the option of conducting and performing Home-Based Learning (HBL) laboratory during current pandemic situation which is especially useful for learner whose learning progress is being affected in the classroom due to Covid-19 pandemic, but still be able to continue doing their laboratory tasks at home and catch up with their study on time when they come back for their scheduled lessons weekly.

Methods

A research study was then conducted to measure the learners' motivation in learning Circuit Testing Anytime & Anywhere using 'NI-myDAQ Student Data Acquisition Device'. In this study, the Intrinsic Motivation Inventory (IMI) (2021) was used to collect the quantitative data, and interview with the selected learners was conducted to collect the qualitative data.
The IMI was developed by Ryan (1982) and his colleagues from the Rochester Motivation Research Group. It has been widely used in studies related to intrinsic motivation and self-regulation (Wang et al., 2011; Loukomies et al., 2013). The IMI comprises seven subscales with 45 items. The seven subscales are interest/enjoyment, perceived competence, effort/importance, value/usefulness, pressure/tension, perceived choice, and relatedness. For every item, the learners taking part in the survey must indicate how true the statement is describing their experience while performing a given activity on a Likert scale from 1 (not true at all) to 7 (very true). Of the seven subscales, five were determined to be relevant to this investigation. We excluded the subscale on perceived choice and relatedness as all the learning tasks and activities were compulsory for all learners taking the module. The five subscales with a short description on the dimension that they measure are listed below, and the questionnaire items are listed in Table 2. The thirty questionnaire items were randomized in their sequence before they were presented to the learners in the form of a survey.

1) Interest/Enjoyment – learners who enjoy doing an activity are more motivated.
2) Perceived Competence – learners who perceive themselves competent in doing an activity are more motivated.
3) Effort/Importance – the amount of effort a learner puts in for an activity or the level of importance a learner assigns to an activity is considered highly relevant to his/her level of motivation.
4) Value/Usefulness – an aspect that is related to one's internalization of an experience.
5) Pressure/Tension – learners who experience pressure or tension in doing an activity are less motivated.

Table 2. Selected 5 IMI Subscales and Questionnaire Items

Interest/ Enjoyment	Perceived Competence	Effort/ Importance	Value/Usefulness	Pressure/Tension
• I enjoyed doing electronic circuits testing very much with[*1]/without[*2] 'NI-myDAQ card'. • Electronic circuit testing & analysis was fun to do with[*1]/without[*2] 'NI-myDAQ card'. • I thought electronic circuit testing & analysis with[*1]/without[*2] 'NI-myDAQ card' was a boring activity. (R) • Electronic circuit testing & analysis with[*1]/without[*2] 'NI-myDAQ card' did not hold my attention at all. (R) • I would describe the electronic circuit testing & analysis as very interesting with[*1]/without[*2] 'NI-myDAQ card'. • I thought the electronic circuit testing & analysis was quite enjoyable with[*1]/without[*2] 'NI-myDAQ card'. • While I was testing my electronic circuits, I was thinking about how much I enjoyed it with[*1]/without[*2] 'NI-myDAQ card'.	• I think I am pretty good of testing electronic circuits with[*1]/without[*2] 'NI-myDAQ card'. • I think I did pretty well of electronic circuits testing compared to other learners with[*1]/without[*2] 'NI-myDAQ card'. • After working at electronic circuits testing for a while with[*1]/without[*2] 'NI-myDAQ card', I felt pretty competent. • I am satisfied with my performance of testing electronic circuits with[*1]/without[*2] 'NI-myDAQ card'. • I was pretty skilled of testing electronic circuits with[*1]/without[*2] 'NI-myDAQ card'. • I couldn't do very well for electronic circuit testing & analysis with[*1]/without[*2] 'NI-myDAQ card'. (R)	• I put a lot of effort into electronic circuit testing & analysis with[*1]/without[*2] 'NI-myDAQ card'. (R) • I didn't try very hard to do well for electronic circuit testing & analysis with[*1]/without[*2] 'NI-myDAQ card'. • I tried very hard on electronic circuit testing & analysis with[*1]/without[*2] 'NI-myDAQ card'. • It was important to me to do well at electronic circuit testing & analysis with[*1]/without[*2] 'NI-myDAQ card' • I didn't put much energy into electronic circuit testing & analysis anytime & anywhere with[*1]/without[*2] 'NI-myDAQ card'. (R)	• I believe 'NI-myDAQ card' could be of some value to me in helping me for electronic circuit testing. • I think 'NI-myDAQ card' is useful for promoting my interest in learning electronic circuit testing. • I think this is important to use 'NI-myDAQ card' because it provides me with the flexibility for circuit testing anytime & anywhere. • I would be willing to use 'NI-myDAQ card' again because it has some value to me. • I think using 'NI-myDAQ card' could help me to improve my circuit testing and troubleshooting skills. • I believe using 'NI-myDAQ card' could be beneficial to me. • I think 'NI-myDAQ card' is an important support to allow electronic circuit testing anytime & anywhere.	• I did not feel nervous at all while testing electronic circuits with[*1]/without[*2] 'NI-myDAQ card'. (R) • I felt very tense while testing electronic circuits with[*1]/without[*2] 'NI-myDAQ card'. • I was very relaxed in testing & analysis my electronic circuits with[*1]/without[*2] 'NI-myDAQ card'. • I was anxious while working on testing & analysing my electronic circuits with[*1]/without[*2] 'NI-myDAQ card'. (R) • I felt pressured while testing electronic circuit with[*1]/without[*2] 'NI-myDAQ card'.

Notes:
The items marked with (R) are negative statements. To calculate the item score, subtract the item response from 8.

**1: Survey Questionnaires for learners who opted in to use the 'NI-myDAQ' device to support circuit testing after scheduled lessons.*

**2: Survey Questionnaires for learners who opted out and performed the circuit testing in the laboratory using multimeter and oscilloscope*

Full autonomy was given to learners to decide if they would like to use the myDAQ device after the scheduled laboratory lessons. Sixteen learners opted for it, and they were put in a group named as an autonomy group. The other sixteen learners who opted out but have similar academic profiles (Table 3, i.e. similar in terms of class size, average 'O' level aggregate and ITE GPA, and ratio of ITE graduates to 'O' level graduates) were selected and they were put in another group named as the comparison group. The same lecturer was assigned to teach this module for the laboratory sessions and all the learners were taught in the same way using the same materials. By choosing a comparison group with the similar profile and assigning the same lecturer to teach all the learners, the effect of extraneous variable is minimized, and the threats to internal validity are reduced. These thirty-two learners from the autonomy and the comparison groups took part in the IMI survey at the end of the semester when they had completed their project.

Table 3. Profiles of the two groups of learners

	Autonomy Group	Comparison Group
Class Size	16	16
Proportion of 'O' Level Graduates	93.75%	93.75%
Average 'O' Level Aggregate	13	13
Proportion of ITE Graduates	6.25%	6.25%
Average ITE GPA	2.93	2.92

Results and Discussion

The results of the survey are summarized in Table 4. The effect size of each of the five IMI subscales between the two groups of learners was then computed based on [1] Cohen's criteria ("Effect Size (ES)", 1996). The outcomes are shown in Table 5.

Table 4. Results of Survey Using IMI

IMI Subscales	Autonomy Group (16)		Comparison Group (16)	
	Average Rating	Standard Deviation	Average Rating	Standard Deviation
Interest/ Enjoyment	5.08	1.08	4.52	0.67
Perceived Competence	5.36	0.86	4.26	0.66
Effort/ Importance	4.44	0.60	4.34	0.56
Value/ Usefulness	6.13	0.63	4.58	0.67
Pressure/ Tension	3.49	1.00	3.38	0.83

Table 5. Effect Size Computations Based on Cohen's d Criteria

IMI Subscales	Cohen's d	Effect Size
Interest/ Enjoyment	0.67	Medium
Perceived Competence	1.86	Large
Effort/ Importance	0.3	Small
Value/Usefulness	3.66	Large
Pressure/Tension	0.13	Very Small

The results from this investigation using IMI indicate a significant difference in learners' self-report of the perceived competence subscale (the large effect size of 1.86) and the Value/Usefulness subscale (the large effect size of 3.66). There is evidence that the learners who had used the myDAQ device appreciated the value or usefulness of the device, which had helped them to enhance their motivation in learning circuit testing, and they also perceived themselves to be more competent as compared to other group who had opted-out. There is also evidence that learners who had used the myDAQ device showed higher interest and enjoyed circuit testing with the device (the medium effect size of 0.67), as it provided them with the convenience of circuit testing anytime & anywhere. These quantitative results were encouraging and revealed that using the myDAQ device for circuit testing is effective in enhancing learners' motivation in learning circuit testing anytime & anywhere.

There is a small difference in the result between the two groups of learners on the effort or important subscale. This small difference observation is expected as myDAQ device is not the testing instrument used for the laboratory assessment, and learners might place less importance on the use of the myDAQ device in the survey. The main concern that the learners have is the myDAQ device allows learners who need more time for learning to continue their circuit testing and troubleshooting with the convenience of anytime & anywhere after the scheduled laboratory lessons. This self-learning pace had provided them with more time to develop their technical skills as well as enhance their motivation and confidence in learning. These skills improvement observation have been indicated in the preceived competence subscale with a significant difference shown between the two groups of learners. As for the results on the pressure or tension subscale, the difference is insignificant. According to Hattie (2012), educational interventions with effect size above +0.4 were considered worth having, hence the overall results were still encouraging and only a trivial effect size was observed on the subscale of Pressure/Tension with a value below +0.2.

Six learners who had used the myDAQ device for circuit testing were selected for the interview. Through the interview, their views on enhancing learners' motivation in learning circuit testing anytime & anywhere using myDAQ device were further revealed. The interviewees commented that myDAQ device allowed them to have more time for circuit testing anytime & anywhere, and the self-paced learning and testing pedagogy used in the laboratory were very motivating and interesting, especially useful for slow-paced learners in the classroom. They also pointed out that they faced challenges initially when they experienced circuit connection failures during the troubleshooting stage when they have to do the testing at home. However, with the testing and troubleshooting guided materials provided by the lecturer for self-learning, and the flexibility of circuit testing with the myDAQ device, it has provided them with more time to

[1] Cohen (1988) defined effect sizes as "small, d=0.2", "medium, d=0.5" and "large, d=0.8". A "small" and 'large" effect size implies the difference between the two sample sizes is trivial and substantial respectively.

learn and to develop the circuit testing and troubleshooting skills. Though the interviewees appreciated the usefulness of the myDAQ device that gave them more time to acquire the technical circuit testing and troubleshooting skills, their techincal skills have been improved, and became more motivated in learning the circuit testing related skills.

Conclusions

The adoption of the myDAQ device to provide the flexibility of circuit testing anytime & anywhere after the scheduled laboratory lesson for AES module has been a successful effort. The surveys and interviews conducted with the learners affirm the effectiveness of this approach in enhancing the learners' motivation in learning circuit testing. However, the sample size of this study was limited by the small cohort size for those who are voluntarily to use the device, so moving forward, the use of the myDAQ device for circuit testing approach on learners' motivation will be extended to a larger scale that covers more learners.

With the encouraging results from this small-scale investigation, more lecturers are encouraged to use the myDAQ device to support circuit testing anytime & anywhere in their modules. Nonetheless, we acknowledge that there are some challenges in adopting this approach, such as the laboratory learning activities, the circuit testing and trousbleshooting materials used to guide learners for circuit testing using myDAQ device need to be put in place to scaffold the learners in learning circuit testing and troubleshooting skills anytime & anywhere. Feedback from the learners also play an important part in helping the lecturers to fine-tune the learning activities to ensure that the use of the my-DAQ device is meaningful, so the learners gain fruitful learning experience in enhancing their motivation and capabilities in circuit testing and troubleshooting.

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PILOT STUDY ON USING BRIGHTSPACE'S LEARNING ANALYTICS TO ENHANCE STUDENTS' LEARNING IN A DIGITAL ELECTRONIC MODULE

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Abstract

Singapore Polytechnic (SP) is moving towards a digital culture where lecturers will be using data on student performance (e.g., learning analytics) to improve teaching and learning strategies. This pilot study seeks to capture key aspects of the student learning experience in using SP's new learning management system, BrightSpace, which can capture students' learning performance data instantaneously. The aim is to be able to diagnose student learning gaps (e.g., knowledge/conceptual understanding, and misconceptions) and, from this insight, be able to provide focused and differentiated feedback. The research used a broad action research approach involving one class of 19 students taking a Digital Electronics (DE) module which they had previously failed. The methodology employed a questionnaire that included both quantitative questions using a rating scale on key dimensions of the learning experience, as well as open response items where students made personalized videos of their experience. In addition, semester examination results have been analyzed and triangulated. The instructional approach involved pre-class quiz results which provided insights on students' understanding through timely analysis, from which teaching faculty can design and facilitate appropriate pedagogic interventions. Students did a graded quiz and exit poll before the end of the class and results were analyzed to close any learning gaps. The findings are positive, both in terms of attainment and student feedback. Students who stayed on the course passed the DE module, and their feedback indicated a high level of engagement (e.g., strongly agree) relating to the dimensions evaluated. The combination of the activities used and the opportunities for questioning provided in the approach, supported by learning analytics, seems to be the major factor in enhancing the student learning experience. In summary, this study supports the use of learning analytics in offering heightened capability to make immediate diagnosis and pedagogic option generation for feedback responses.

Keywords: *learning analytics, feedback, differentiated instruction, action research, formative assessment*

Introduction

Singapore Polytechnic (SP) is moving towards a digital culture where teaching faculty, who have long been using EdTech, and are now increasingly using data on student performance (e.g., learning analytics in a Learning Management System) to improve their teaching and learning strategies.

SP has been implementing Asynchronous Lectures since 2020 in response to the need for home-based learning due to Covid-19. There is data from the Asynchronous Lectures that can be collected, analyzed, and interpreted to provide greater insight on student learning in increasingly specific and personalized ways.

These insights will enable teaching faculty to make more useful and focused pedagogic decisions actions in preparation for the face-to-face tutorials to ensure that students are able to complete all tasks at their own pace.

Assessing Learning Regularly for Timely Support (ALeRT) is another SP's initiative to support its digital culture. A key element of ALeRT is the use of Learning Analytics (LA) to diagnose learning difficulties regularly and enable teaching faculty to customize learning or design pedagogic interventions based on student feedback in a timely manner.

The Digital Electronics module has implemented both Asynchronous Lectures and ALeRT. However, in the implementation of both initiatives the data collected were in different formats which required an additional step of using Robotic Process Automation (RPA) and Power Bi - an interactive data visualization software (Tan et al., 2021). In this pilot study, we attempted to use SP's Learning Management System (LMS) to collect data in one place with easy-to-use dashboards that allow teaching faculty to obtain both specific insights on student learning and make appropriate pedagogic interventions, especially relating to feedback on performance to remedy knowledge gaps. In summary, this enables the collection of relevant data on student learning through the Asynchronous Lecture, which is part of ALeRT, the design of appropriate pedagogic interventions for tutorials based on derived insights, and then the deployment of ALeRT again to check to see if the interventions are working.

This pilot study seeks to capture key aspects of the student learning experience in using SP's new LMS, BrightSpace, which can instantly capture students' learning performance data. The aim is to be able to

diagnose student learning gaps (e.g., knowledge /conceptual understanding, and misconceptions) and, from this insight, be able to provide focused and differentiated feedback.

The specific research questions are as follows:

1. What was the impact on the student learning experience with the provision of more focused and differentiated feedback?
2. Which aspects of BrightSpace's learning analytics were most useful in diagnosing student learning gaps?
3. What are the areas for further improvement and future research opportunities?

Literature Review

ALeRT seeks to utilize the capability of LA to better understand student learning, and then enhance instructional effectiveness and efficiency – especially the provision of focused feedback and differentiated instruction.

Central to ensuring that the affordances of these technologies are fully utilized is the need to employ an evidence-based pedagogic approach. There is now a strong evidence-base relating to how best to design and facilitate the various practices we call teaching that can significantly enhance student learning opportunities and attainment levels. This has resulted from increasing knowledge relating to how humans learn, what teaching methods and practices work best and why, and an unpacking of what the best teaching practitioners do and how. This research and its applications are well documented in the literature (e.g., Hattie 2008; Willingham 2009; Bain, 2012).

LA collects, analyzes, and presents data in highly visual ways about learner's performance. There are two broad aspects to LA for the purpose of this research as framed by Admiraal et al. (2020):

> "Embedded analytics refers to data that are used to inform the learner and/or to adapt tasks to the ability levels of students without teacher intervention. An advantage of embedded analytics is that these can be used seamlessly during participation in the learning activity itself. A weakness is that the learner can ignore these analytics."

> "Extracted analytics refers to data that are presented for interpretation and provide teachers with information about learning process and outcomes, which they use to improve their classroom instruction."

The pedagogic benefits include:

1. Identifying learners' understanding and performance levels in designated learning areas and tasks
2. Diagnosing learner's knowledge gaps and misconceptions
3. Customizing and personalization of instruction to individual learner needs and specific conceptual/skill areas
4. Providing an ongoing evidence-based for future instructional planning

The benefit of being able to assess student learning instantaneously is that it enables teaching faculty to, (1) gain insight into what students understand or don't understand in the immediate learning context, and (2) provide timely and focused feedback to facilitate the necessary remediation in situ. Research has consistently shown that activities that enable such quality feedback constitutes a key strategy for enhancing educational attainment. For example, the extensive meta-analysis of research on the effectiveness of different teaching methods by Hattie (2008) recorded an average Effect Size of 0.73 for feedback (i.e., students getting feedback on their work from the teacher, peers, self, or others).

There are many interrelated aspects that contribute to the high impact potential of feedback on learning. Hattie & Timperley (2007) proposed a model of feedback to identify the properties and circumstances under which the feedback has the greatest impact. To make feedback effective, teachers needs to make judgements about when, how and at what level to provide feedback. Nicol & MacFarlane-Dick (2006) in synthesizing the research literature suggest the following seven principles of good feedback practice:

1. helps clarify what good performance is (goals, criteria, expected standards)
2. facilitates the development of self-assessment (reflection) in learning
3. delivers high-quality information to students about their learning
4. encourages teacher and peer dialogue around learning
5. encourages positive motivational beliefs and self-esteem
6. provides opportunities to close the gap between current and desired performance
7. provides information to teachers that can be used to shape teaching (p.203)

Furthermore, effective teachers - just as they adjust their communication style to different student personalities - also adjust their provision of feedback accordingly based on students' need in different contexts. For example, Hattie and Yates (2014) suggest that novices require more specific task-related corrective feedback, to be gradually replaced with more process feedback as they become increasingly proficient and self-regulated in their learning. Process feedback is more focused on how the students are tackling the tasks given, such as their thinking (e.g., analyzing, comparing, making inferences & interpretations, evaluating) and the learning strategies they are using.

In providing feedback it is often the case that both aspects are needed, and this is where the teacher's

judgement and skillful action are most impactful. As students become increasingly proficient, feedback is usually more focused on their abilities to monitor and evaluate their own learning, both at cognitive and affective levels (e.g., metacognition).

The LA provided in ALeRT mainly enables teaching faculty to immediately provide effective and efficient task and process feedback, which will help students to develop the necessary conceptual understanding of subject content in an online learning environment.

Methodology

The study used an Action Research (AR) approach involving one class of 19 students re-taking a Digital Electronics (DE) module, which they had previously failed.

AR primarily seeks to better understand and improve an aspect(s) of practice – in this case how learning analytics in BrightSpace can be leveraged on to design interventions to enhance student learning experience (e.g., Carr & Kemmis, 1986; Sagor, 2000). While AR may not produce highly generalizable finding through extensive experimental surveys, it does as Stringer (2004) noted:

> "encapsulate the systematic qualitative research routines now becoming commonplace in the educational arena and increasingly applied by teachers and administrators as part of their work in schools. (p.6)"

The scope of the study involved 3 topics in the Digital Electronics module, mainly Number Systems, Boolean Algebra, and Combinational Logic Circuit Design. Each topic consists of one-hour self-directed asynchronous lectures and two-hour face-to-face tutorial lessons. At the end of each lesson, the lecturer and pilot study team reflect on the effectiveness of the learning design and discuss how to better leverage on BrightSpace's data to improve learning design for the next lesson.

The instructional approach involved pre-class quiz results which provided insights on students' understanding through timely analysis, from which teaching faculty can design and facilitate appropriate pedagogic interventions to enable all students to complete all tasks in class at their own pace. To check that the pedagogic interventions were working well, students did a graded quiz and exit poll half an hour before the end of the class. Results were analyzed and used to close any learning gaps before the end of the tutorial or for next lesson planning. The learning design of a typical lesson, detailed lesson designs and Edtech tools used for each lesson are in Appendix 1.

The data collection methodology employed a questionnaire (see Appendix 2) that included both quantitative questions using a rating scale on key dimensions of the learning experience, as well as open response items where students made personalized videos of their experience. Semester examination results were also analyzed and triangulated.

Results

BrightSpace's Graded Quiz Statistics were used for analyzing data. Quiz statistics include user statistics, question statistics, and question detail.

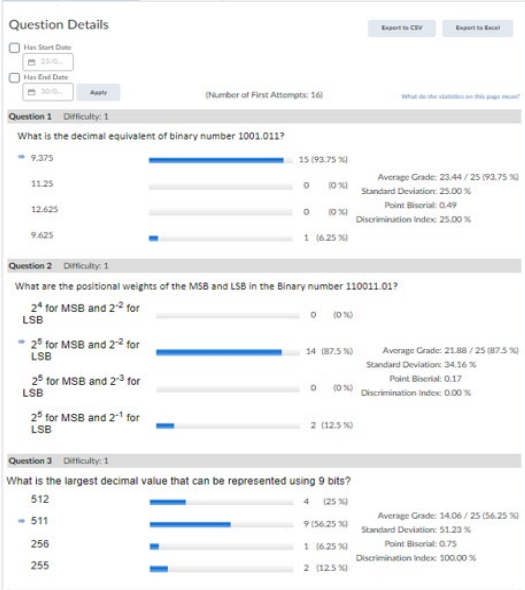

Figure 1: Question Details

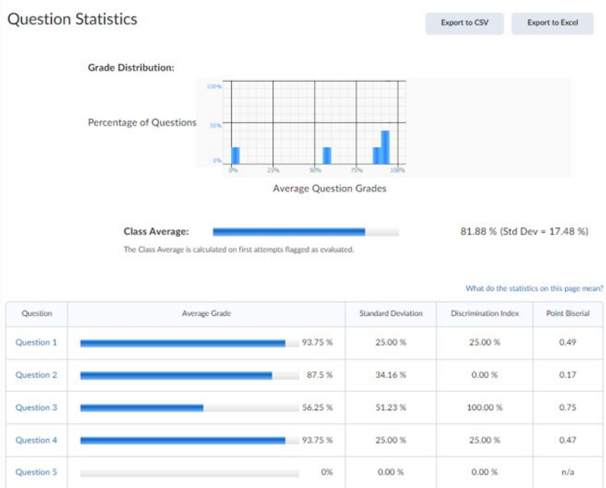

Figure 2: Question Stats

The lecturer looked at question details (Figure 1) and question stats (Figure 2) to see which questions the students were having problems with. For example, based on the graded quiz for Number Systems, students did not seem to understand Question 3 as only half the class got it correct and half the class chose other options. This showed that many students did not really comprehend the deeper meaning of decimal numbering systems. Based on this perception, the lecturer did a 'just-in-time' teaching

input and gave more examples before class ended to try to close this learning gap. The graded quiz was conducted 30 min before the class ended as the lecturer decided that it would be more effective for student learning to clarify and address misconceptions immediately, instead of waiting until the next lesson. Hattie & Timperley (2007) highlighted the importance of the timing of feedback to maximize the power of feedback and the decision to do intervention immediately instead of waiting till the next lesson was proven to be effective.

Figure 3: User Stats

The user stats (Figure 3) were analyzed to highlight potential "at-risk" students. The lecturer then designed interventions using an appropriate method(s) (e.g., peer teaching, short video). Students were directed to attend a mandatory two-hour supplementary lesson weekly if their scores did not show improvement.

10 out of 19 students responded to the questionnaire. The summary data from the fixed response items in the questionnaire are presented below in Figure 4.

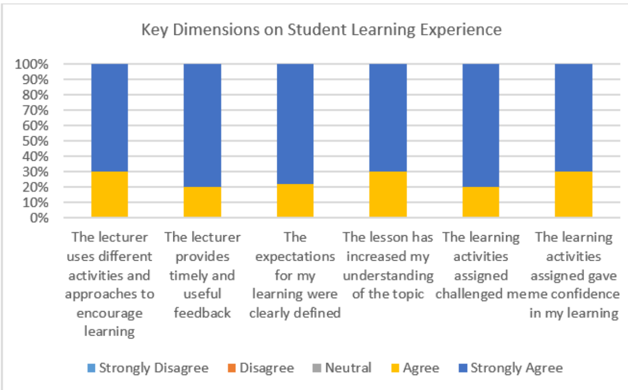

Figure 4: Key Dimensions on Student Learning Experience

The data relating to student learning experience is highly positive, with 100% responding in the combined 'Agree' and 'Strongly agree' response options for all dimensions. It is interesting to note that 70-80% of students chose "Strongly agree" and no student chose "Neutral". This suggests that the pedagogic interventions (e.g., focused and timely feedback) were effective and students felt that their understanding and confidence of the topic had increased.

For the open response items, where students made personalized videos of their experience, content analysis were done after the video were transcribed. The data from the open response items identify the key aspects which supported and hindered student learning.

Table 1 listed the aspects which supported student learning.

Table 1: Aspects which Supported Student Learning

Students' responses	No. of counts
Pre-class learning e.g., videos and pre-class quiz	2
Tutorial activities e.g., more challenging questions and exam questions	8
Checking for students understanding verbally in class and closing learning gaps	4
Giving students a chance to ask questions	2
Use of BrightSpace to facilitate learning e.g., checklist	3

Most students identified the learning activities during tutorials as being the most useful to their learning. These activities were differentiated at the beginning of class based on pre-class quiz results. Students who scored more than 80 marks did more challenging questions on their own while the teaching faculty focused on students who scored less than 80 marks. 80 marks was chosen because the pre-class quiz was designed to be relatively easy. It was mainly for students to check their understanding of basic concepts and to give them confidence in the topic. This differentiated instruction was noted in the open response item where students identified the different tutorial activities that most supported their learning. Some quotes from the students include:

> "going through difficult tutorial questions helped to support my learning"

> "those exam questions which will really help to prepare us for exam"

This aligned with the fixed response item in which 70% of the students 'strongly agree' that there was different activities and approaches to encourage learning. Also, 80% of the students 'strongly agree' that the assigned learning activities challenged them. This suggested that the pre-class quiz result was a good indicator and students were assigned activities which were appropriate to their ability level.

Another key aspect which came out in the students' responses was the teaching and facilitation skills of the teaching faculty. The students highlighted the opportunity to clarify doubts and ask questions in class were very helpful in their learning. Some quotes from the students include:

> "Mr Wan will always ask if we have any questions during the lesson, and if we do have questions, he will answer and then he will explain thoroughly until we understand"

> "I really like this teaching style and learn much better as compared to previous semester where I didn't understand most of the things and was not really given a chance to ask questions..."

The use of BrightSpace to deliver learning content was mentioned as well. Students liked the convenience that they can access all the materials in one place and the checklist feature in BrightSpace helped them to monitor their own progress. Quotes from the students include:

> "In BrightSpace, I think the checklist is the most useful one. I can see what I have done, and of course my progress."

> "Everything is in BrightSpace helped me a lot. I don't need to go to WhatsApp chat to find Exit Poll and pre-class links. Everything can be done easily within BrightSpace."

Table 2 listed the aspects which hindered student learning.

Table 2: Obstacles to Student Learning

Students' responses	No. of counts
No obstacles	4
Weekly graded quiz	1
Being lazy and not so motivated	1
Lecturer was too fast in explaining some questions	1
The quality of some were not as good as others	1

Most students commented that there were no major obstacles in their learning. Among these students, most of them scored very well during exam, ranging from 69-87 marks, which were the upper range of the scores for this class. One student didn't like the weekly graded quiz as it has caused stress in his learning. This student eventually passed the exam with 61 marks. Another student commented that the quality of some videos was not as good as others, and this hindered his learning. The same student also commented that the lecturer's explanation for some questions were too fast, and he could not fully understand. However, of note, this student passed the exam with 69 marks, which was the third highest score among his classmates in this class.

Interestingly, one student reflected that the obstacle to his learning was his own behaviour and attitude towards learning. This student also passed the exam with 64 marks. His exact quote as below:

> "Obstacle for my learning will actually be being lazy. So actually sometimes I will get a bit too lazy and not so motivated to continue with lesson, but with the theory lesson and the practice that was given in class, I feel it has helped me to push on…"

Table 3 shows the exam results, pre-class quizzes and graded quizzes of the students who have passed the DE module. Table 4 presents the reasons for the students who withdrew from the course.

Table 3: Results of Students who Passed DE module

Name	Exam Result	Wk 3 Pre-Class	Wk 3 Graded	Wk 4 Pre-Class	Wk 4 Graded	Wk 5 Pre-Class	Wk 5 Graded
Student 3	87	50	100	25	100	50	100
Student 6	83	100	100	75	100	x	100
Student 4	69	100	100	75	100	75	100
Student 18	69	100	x	50	100	100	25
Student 14	69	100	75	75	100	75	0
Student 10	64	100	100	100	100	100	50
Student 9	61	75	50	25	x	50	50
Student 17	57	75	50	75	100	75	75
Student 5	55	100	50	x	x	75	50
Student 19	50	75	75	x	x	50	x

x means absent or quizzes not attempted

Table 4: Reasons for not completing DE module

Student(s)	Reasons
Student 1, 2 & 8	Financial difficulties e.g. parents were retrenched during Covid-19 and they have to work to support their family
Student 7	Health issue
Student 11	Lost interest in study
Student 12, 15 & 16	Failed many modules and were removed by SP
Student 13	Cannot cope with Maths and withdrew from the course

In summary, ten students passed the DE modules with scores ranging from 50 marks to 87 marks. Six students withdrew from the course and three students were removed by SP.

Three weeks of data on pre-class and graded quizzes were not sufficient to analyze any correlations to the exam results. However, it was observed that the students who did well in the exam (e.g., Students 3 and 6) consistently did well in their graded quizzes (e.g., scored 100 marks as shown in Table 3). Their pre-class quizzes scores varied but the teaching faculty noticed that these students consistently asked questions in class and provided feedback on their learning (the notable behaviours observed by the teaching faculty is in Appendix 3).

Analysis and Implications for Practice

In terms of the specific research questions of this pilot study, it can be inferred that the approach taken has been successful both in terms of attainment and engagement. Of particular interest is the more qualitative and specific aspects of the learning experience that are of primary interest, such as the students attention and engagement in the various aspects of this learning event. Getting good attention is important as Miller (2016) States:

> "Optimizing your learning experiences for attention is the first step towards optimizing it for long-term memory and higher thought processes. (p.8)"

Similarly, engagement is fundamental to effective learning and has different dimensions including:

- Behavioural (on-task attention, effort, persistence)
- Emotional (presence of interest, enthusiasm)
- Cognitive (use of thinking, learning strategies)

What is notable in the student responses is that they have been engaged across these 3 dimensions, which would indicate that they have been intrinsically motivated in doing the activities set and the facilitation style employed. Apart from the design of the initiative, the use of challenging learning activities and supportive questioning seems to have been two specific effective pedagogic components.

There is a strong evidence base supporting the importance of establishing clear, meaningful, and challenging goals for learners. For example, Hattie (2008) found an effect size of 0.56 for Challenging Goals and highlighted that:

> "...effective teachers set appropriately challenging goals and then structure situations so that students can reach these goals. If teachers can encourage students to share a commitment to these challenging goals, and if they provide feedback on how to be successful in learning as one is working to achieve the goals, then goals are more likely to be attained. (p.165)"

Similarly, questions are small activities which impact all aspects of the learning process. As Robbins (2001) argued:

> "Thinking itself is nothing but the process of asking and answering questions (pp.179-8)"

The very nature of posing a question suggests some knowledge gap or misconception in long term memory, hence the question. Using the LA in BrightSpace, teaching facility can immediately identify the student learning difficulty. In basic terms, they can address the essential question of 'what do my students know and what they do not know specifically'. This then enables the opportunity to prepare the most effective and personalized pedagogic interventions and feedback necessary, including other probing questions that may be required to gain further insights where necessary.

The combination of the activities used and the supporting ongoing opportunities for questioning provided in the approach, and supported by learning analytics, seems to be a major factor in enhancing the student learning experience. It will be essential, therefore, that upscaling the initiative will require all teaching faculty to develop the capability to design challenging activities that are appropriately differentiated, diagnose specific learning difficulties from the data provided, and use skillful questioning in the facilitation process.

As in most innovations, practice over time is essential, and this must be recognized in the future wider implementation for other teaching faculty. To become competent and eventually expert in any new pedagogic strategy, even for experienced teachers, takes much deliberate practice and effort, as Levin (2008) noted:

> "To get good at a new practice takes time and effort in schools – whether as a teacher or principal or superintendent. (pp.80-81)"

Similarly, as Gulamhussein (2013), emphasized:

> "The duration of professional development must be significant and ongoing to allow time for teachers to learn a new strategy and grapple with the implementation problem. (p.3)"

Limitations and Future Recommendations

As BrightSpace was not fully implemented when this pilot study took place, only quiz statistics were being analysed and action was limited to this data source. However, as there are more dashboards such as class engagement, class progress, and SCORM reports available in the full version, a much wider range of data will be available and, therefore, the potential of data triangulation to offer both more holistic and specific insights into the students' learning experiences. In turn, teaching faculty will be able to develop their capability to provide the most effective pedagogic interventions with high predictability for meeting diverse student learning needs.

Also, at that time during the pilot, Blackboard was still the official learning management system, and only 3 topics were piloted to minimize disruptions to the student learning experience. To fully examine the impact of BrightSpace's learning analytics on student learning, more topics need to be facilitated using the learning approach and design methodology outlined earlier. Invariably, the methodology may need enhancement in view of the additional dashboards provided.

In summary, however, the study offers support of the use of LA in offering heightened capability to make

immediate diagnosis and pedagogic option generation for feedback responses, something not easily attained previously. This is consistent with other findings that support its use, especially when it is used from an evidence-based pedagogic approach, as was the case in this pilot study. For example, Ferguson et al (2016) pointed out:

> "…successful analytics do not begin with a set of data; they begin with an understanding of how people learn. (p.38)"

Similarly, as emphasized by Nunn et al (2016), quoted in Kleimola & Leppisaari (2012):

> "… the value of LA in promoting future competences is strongly connected to the pedagogic and assessment regime emphasized in educational institutions."

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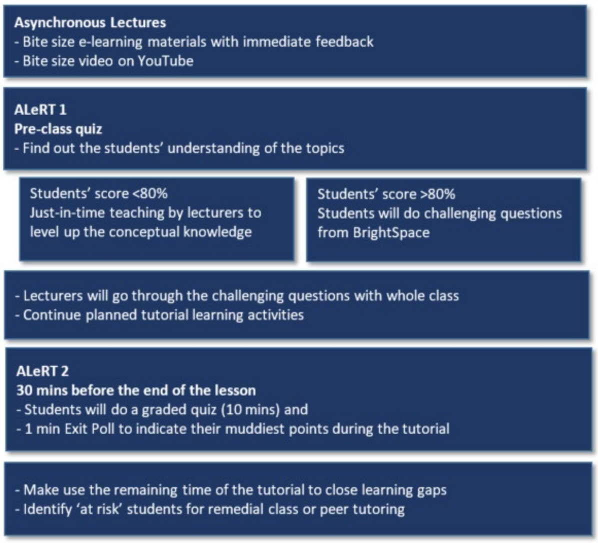
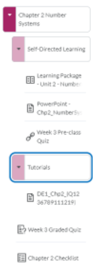
Appendix 1: Learning Design and Implementation Details of the Piloted Lessons

Learning Design of a Typical DE lesson

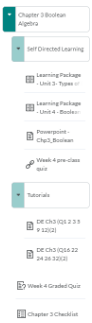


Implementation Details of the Piloted Lessons

Week 3



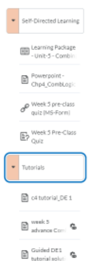
- Chapter 2 –Number Systems
- Asynchronous material (SCORM articulate rise & PPT) in BrightSpace (BS)
- Pre-class quiz, we used MS-FORM, we put a link in BS for students to access
- If students did well in the pre-class quiz, I gave them some challenging questions while I ran through the class quiz with the rest. (this is not recorded in BS)
- Face to face (FTF) tutorial, 30 mins before the end of the tutorial, we do an exit poll and graded quiz
- Tutorial questions in BS
- Graded quiz in BS
- Exit Poll in MS-FORM



Week 4

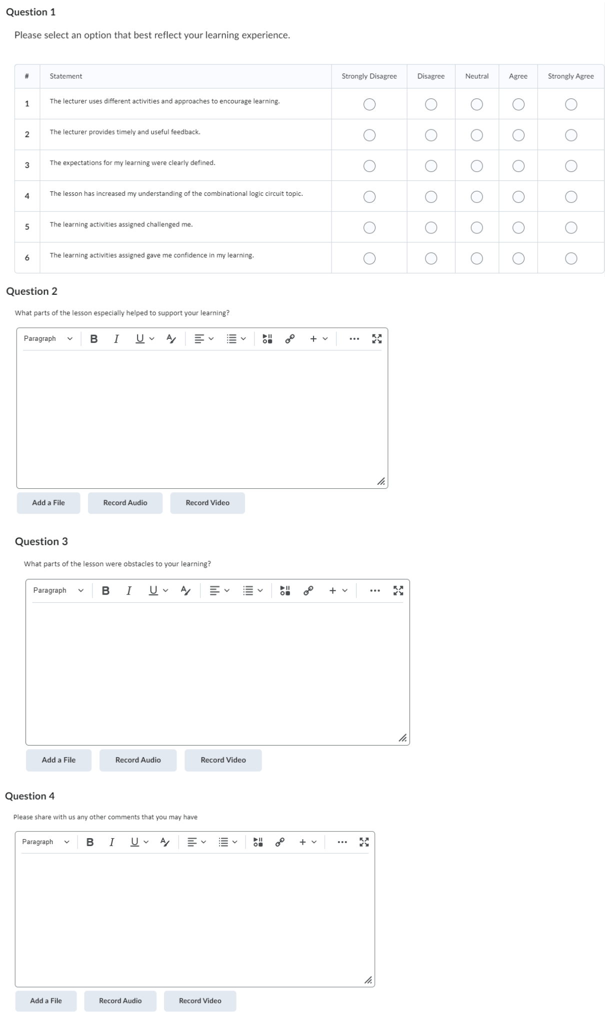
- Chapter 3 – Boolean Algebra
- Asynchronous material (SCORM articulate rise & PPT) in BrightSpace (BS)
- Pre-class quiz, we used MS-FORM, we put a link in BS for students to access
- If students did well in the pre-class quiz, I gave them some challenging questions while I ran through the pre-class quiz with the rest of the students. (not recorded in BS)
- FTF tutorial, 30 mins before the end of the tutorial, we do an exit poll and graded quiz
- Tutorial questions in BS
- Graded quiz in BS
- Exit Poll in MS Form

Week 5 (we use BS to do all activities)



- Chapter 3 – Combinational Logic Circuit Design
- Asynchronous material (SCORM articulate rise & PPT) in BrightSpace (BS)
- Pre-class quiz and exit poll, we implemented in BS as well as provided a link for MS FORM
- Graded quiz implemented in BS, using random block
- We deployed adaptive release learning experiences for Tutorial
- FTF tutorial, 30 mins before the end of tutorial, we do exit poll and graded quiz

Appendix 2: Survey on Student Learning



Appendix 3: Exam Results

Exam Results and notable behaviours observed by the teaching faculty

Name	Exam Results	Learning Behaviour
Student 1		Withdrew from course
Student 2		Withdrew from course
Student 3	87	Student 3 did not go through the Asynchronous Lecture materials, thus did not do well for pre-class quizzes (25-50 marks). However, she was attentive in class and always asked questions to clarify her doubts. This was evident in her graded quizzes results, 100 marks.
Student 4	68.6	Student 4 was trying hard to cope as he had to work part-time to support his family.
Student 5	54.6	Student 5 had difficulty grasping concepts. However, he put in extra effort to learn and always asked questions in class. He managed to pass.
Student 6	82.7	Student 6 showed good learning capability. He was attentive in class and always asked questions.
Student 7		Withdrew from course
Student 8		Withdrew from course
Student 9	60.5	Student 9 is a slow learner, he put in a lot of effort to study and passed the exam. He always asked questions in class to clarify his doubts.
Student 10	64.2	Student 10 is a smart boy but he didn't put in enough effort in study. He can do much better if he were more focused on his study.
Student 11		Withdrew from course
Student 12		Withdrew from course
Student 13		Withdrew from course
Student 14	68.6	Student 14 was struggling between work and study as he has to work part-time to support his family.
Student 15		Withdrew from course
Student 16		Withdrew from course
Student 17	57.2	Student 17 tends to lose focus when come to studying. He asked questions in class though.
Student 18	69	Student 18 was attentive in class and asked questions. He didn't study enough to do well in the exam.
Student 19	50	Student 19 didn't attend class most of the time as she was not interested in the study. But she managed to pass the exam (supplementary paper).

DEVELOPMENT OF TEACHING MATERIALS FOR CUBESAT COMMUNICATION SYSTEM USING AMATEUR RADIO

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Abstract

Recently, many universities and the like operate CubeSat (micro-satellite), and several research institutes have proposed teaching materials for training human resources for related to the space. However, most of the communication systems of the education materials are virtual systems which use the ZigBee standard, etc., and there are few that can experience actual amateur wireless communication. In view of these situations, it is very useful to develop hands-on teaching materials that can quickly acquire wireless communication technologies. Specifically, this function receives commands from the satellite ground station and transmits them to the OBC (On-Board Computer). And, it has two functions, first one dividing the data acquired by the satellite into packets and second one transmits them. These are all performed by amateur radio packet communication. In the past, packet communication on amateur radio used hardware TNCs (Terminal Node Controllers), but currently software TNCs are common. The teaching materials proposed in this research use open source software TNC such as Direwolf.

Another advantage of advocating this teaching material is the active acquisition of satellite information. One of the reasons why many CubeSats adopt amateur radio as a communication method is that they expect to get information from amateur radio homes around the world. The time that a satellite can communicate with one satellite ground station is very short, and it is difficult to universities with limited budgets to install satellite ground stations at multiple points. The teaching materials proposed in this study propose a practical method of receiving radio waves from CubeSat with a simple receiver. If the technology related with radio wave reception spreads with the teaching materials, the opportunity to receive amateur band radio waves of CubeSat will expand, and more active universe utilization can be promoted.

Keywords: *Teaching Materials, Amateur Radio, Software Terminal Node Controllers, CubeSat, Communication System*

Introduction

The development of CubeSats is useful for learning embedded technology, space science, and engineering. However, it is difficult to begin CubeSat fabrication without a certain level of prior knowledge. Therefore, several educational materials have been proposed for acquiring the prior knowledge and skills necessary for CubeSat fabrication (Dirk(2015), Masahiko(2021) Jose(2021) . However, in many cases, existing educational materials use virtual communication modules. Therefore, it is difficult to learn the actual communication technologies of satellites. To solve these problems, we report the results of using the bus satellite part (communication module) of KOSEN-1 as teaching material for technical college students. This chapter describes the contents of the following communication lectures given to students developing KOSEN-1 and its successor satellites. This lecture was given in the "Pre-Space Contest Workshop" held in November 2020.

1. Outline of this Lecture

1.1 Outline of the Pre-Space Contest Workshop

In January 2021, a "Pre-Space Contest" was held for student teams developing KOSEN-1 as a preparatory step for the "National College of Technology Space Contest" to be held in FY2021. In the pre-space test, each student team examined ideas for new missions feasible in space using the KOSEN-1 satellite simulator and a structural model; their ideas were evaluated by external experts online.

The pre-space test workshop provided startup education for the pre-space contest participants. Specifically, we provided hands-on seminars on the development of an onboard computer (OBC) for satellites, courses on various space sciences and engineering, knowledge of basic radio and communications engineering, elemental technologies

required for satellite communications, and courses on how to handle satellite radios and ground station radios.

1.2 Target Students and their Prior Knowledge

This lecture was given to students who were developing KOSEN-1 and its successor satellite (hereafter referred to as KOSEN-X). The participants were students in the main or major course of a technical college(Table 1), and their grades ranged from the first year of high school to the fourth year of university(Table 2). The prior knowledge of the students is presented in Table 3. The main feature of this lecture is that students' prior knowledge of radio engineering and communication engineering varies.

2. Lecture Method and Content

The lectures and demonstrations of communication systems were divided into tutorials and programming for communication systems. Each lecture and demonstration lasted for 60 min. In these lectures, we introduced the elemental technologies for each communication operation procedure. We then provided demonstrations using the actual equipment. The communication procedure for satellite communication in KOSEN-1 is complex. First, we uplink the satellite using the control commands. Next, we command the downlink, and the downlink data after the mission is executed by the satellite. In such operations, we must specify the syntax of the control commands in bytes. Errors in the

Table 1 Department and grade of the students

	Lower grades	Upper grades	Advanced courses
Electrical and Electronic Engineering	7	6	2
Computer Science and Engineering	1	2	0
Mechanical Engineering	0	1	2
Engineering General Studies (Not yet course classified)	3	0	0

Note: For respondents who answered more than one department (e.g., "Electrical and electronics + Information"), they were categorized into the first department (Electrical for "Electrical and Information").

Table 2 List of student grades

Grade	Number [person]
Lower grades (1st to 3rd year high school)	11
Upper grades (1st and 2nd year college students)	9
Advanced courses (3rd and 4th year college students)	4

Table 3 Prior knowledge of students (multiple responses allowed)

Prior Knowledge	Number of students
No prior knowledge	12
Reading magazines on radio communication as a hobby	1
Attending classes on wireless communications, etc.	4
Belonging to a club related to wireless communications	3
Working on a graduation research theme	3
Have obtained or are studying for a related qualification	5

Note: "No prior knowledge" is counted only when no other option is selected.

commands can cause the satellite to stop functioning. However, it is extremely challenging for many people to simultaneously learn basic matters related to communication, an explanation of packet formats, and how to handle terminal node controllers (TNCs).

Therefore, in this lecture, we divided the complex operational sequence of the satellite communication system into steps to explain and demonstrate its principles. It has the advantage that students can learn the principles of satellite communication and the operational sequence at the same time. In the following sections, we present the contents of the communication system tutorial and communication system programming.

2.1 Communication Tutorial

The following topics were covered in the tutorial on communication systems:

(1) Principles of modulation and demodulation
(2) Principles of digital modulation and demodulation
(3) Explanation of the KOSEN-1 communication system

Regarding (1), many students without basic knowledge of radio engineering (principles and purposes of modulation and demodulation, frequency modulation, and amplitude modulation), such as lower-year students of technical colleges and students majoring in mechanical engineering, participated in this training course. Therefore, we explained the communication schemes and the significance of the modulation to the students.

In (2), we dealt with digital modulation and demodulation based on the modulation techniques described in (1) because all communications in KOSEN-1 are digital modulation (frequency deviation modulation). The FCS part of AX.25 used in KOSEN-1 uses a cyclic redundancy check (CRC) to detect errors in data; however, the theory of cyclic codes is required to understand CRC. This is because knowledge of

information and code theory is required, making it too challenging for students in the lower grades of technical colleges. Therefore, the principle of error detection and correction is treated using parity-check codes instead of CRCs.

For (3), we first considered the general CubeSat configuration. Next, we explained the overall system configuration and components of KOSEN-1, corresponding to the general CubeSat system configuration. Then, we explained the specifications of the communication system and configuration of the actual equipment.

2.2 Communication System Programming

The following items were covered in communication systems programming.
(1) Software development using a version control system
(2) TNC configuration methods on the satellite and ground station sides
(3) Communication operation sequence of KOSEN-1.

Regarding (1), KOSEN-1 uses Git as a version of the control system for software development. However, students in the lower grades of technical colleges and students who are not majoring in information engineering often do not understand the mechanisms and usage of version control systems. Therefore, there is a problem that students are reluctant to participate in development. In this lecture, we explained the mechanism of Git, how to participate in the development, and basic operations.

For (2), to perform packet communication in amateur radio, a TNC, which is a device that performs modern functions and AX.25 packet composition, is necessary in addition to radio supporting data communication. KOSEN-1 uses a Raspberry Pi as the TNC for ground station radio and operates packet transmission and reception on the terminal. In this lecture, we explained the mechanism of TNC and demonstrated its actual transmission and reception. For the operation of KOSEN-1, we aim to extend the communication time and improve reliability by installing ground stations at several technical colleges and performing multipoint transmission/reception. The ground stations to be installed in each technical college are considered to be of two types, depending on the facilities and the radio station application: a ground station that performs both downlink and uplink (hereinafter referred to as "control ground station") and a ground station that performs only downlink (hereinafter referred to as "simplified ground station"). In this lecture, we explained and demonstrated a method of packet reception using a software-defined radio (SDR) tuner for simple ground station operation. The lecture also included an explanation and demonstration of a method for receiving packets using the SDR tuner.

In (3), we integrated the content of the previous lectures and demonstrated a series of operations: "When a control command is uplinked from the ground station, the satellite OBC interprets the command, executes the mission, and downlinks the result. A demonstration of this series of operations is presented.

3. Results of Post-Lecture Questionnaire and Comprehension Check

This section presents the results of the questionnaire and the comprehension check. The results were categorized into higher and lower grades, as well as by the presence or absence of prior knowledge, as shown in Table 3. Major-course students were classified into upper grades. Table 4 shows the number of respondents classified according to the above rules. The distinction by the department was not made because it differs from school to school, and students in the lower grades do not belong to a specific department.

Table 4 Classification by grade level and prior knowledge of students

Classification	Number
Upper grades, with prior knowledge	10
Upper grades, with no prior knowledge	3
Lower grades, with prior knowledge	2
Lower grades, with no prior knowledge	10

3.1 Results of Post-Course Questionnaire

Table 5 to Table 10 show the results of the six-question questionnaire administered after the course.

Table 5 New insights gained from the telecommunications tutorial (multiple responses allowed)

	Lower grades		Upper grades	
Prior knowledge	No	Yes	No	Yes
Fundamentals of Telecommunications	9	1	1	3
Basics of modulation and demodulation	8	2	0	4
Basics of digital modulation and demodulation	3	1	1	5
Configuration of KOSEN-1 communication system	3	1	3	6

Table 6 New insights gained from the Telecommunications Programming lecture (multiple responses allowed)

	Lower grades		Upper grades	
Prior knowledge	No	Yes	No	Yes
How Git Works	8	2	2	8
How TNC Works	4	0	3	4
Packet Communication Mechanism	7	1	3	6
Packet Format	2	0	3	6
State Transitions in Communication	3	1	3	7

Table 7 Is it possible to conduct communication experiments at your college?

	Lower grades		Upper grades	
Prior knowledge	No	Yes	No	Yes
All can be put into practice	2	0	0	0
Partially executable	6	2	3	10
I can't put it into practice	1	0	0	0

Table 8 Content you would like us to handle in the future (multiple responses allowed)

	Lower grades		Upper grades	
Prior knowledge	No	Yes	No	Yes
Courses on radio and telecommunications engineering	5	0	2	6
Training on KOSEN-1 specifications	5	1	1	6
Demonstration and hands-on with actual equipment	3	1	2	2
Training on building a program development environment	1	1	0	4

3.2 Results of Post-Training Comprehension Check

After completing the course, a four-question quiz was administered. The contents of the test were as follows. (1) Do trainees have a correct understanding of the types of modulation? (2) Do they understand the role of the TNC? (3) Is the uplink modulation scheme correctly understood? (4) Do students understand the downlink modulation scheme? (4) Do they understand the downlink modulation scheme? The results are shown in Table 11 to Table 14.

■ Results for question (1)
This question presents the waveform of a modulated wave and asks the user to respond to the modulation scheme corresponding to the waveform. The question is as follows.

What is a digital modulation scheme, as shown in the figure, for pre-determining the frequency of the carrier wave corresponding to "0" and "1" of a binary signal (top) and switching the frequency of the carrier wave according to the binary signal (bottom)?

Responses were evaluated based on whether the correct modulation method was selected.

Table 9 Overall evaluation of tutorials on telecommunication systems (4-level evaluation)

	Lower grades		Upper grades	
Prior knowledge	No	Yes	No	Yes
Very informative	8	2	2	6
Somewhat informative	1	0	1	4
Wasn't very informative	0	0	0	0
I didn't find it informative at all	0	0	0	0

Table 10 Overall evaluation of lecture on telecommunication programming (4-level evaluation)

	Lower grades		Upper grades	
Prior knowledge	No	Yes	No	Yes
Very informative	5	2	2	6
Somewhat informative	3	0	1	4
Wasn't very informative	1	0	0	0
I didn't find it informative at all	0	0	0	0

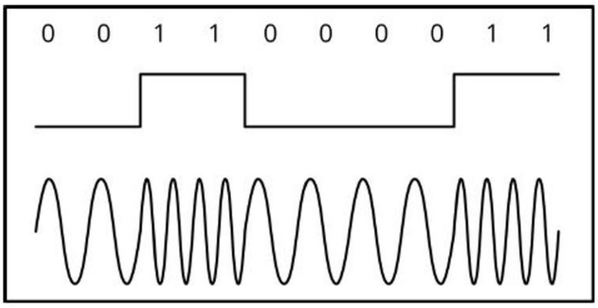

Figure 1 Figure in question

Table 11 Results of question (1)

	Lower grades		Upper grades	
Prior knowledge	No	Yes	No	Yes
Correct	8	2	3	10
Incorrect	2	0	0	0

■ Results for Question (2)
This question was designed to check whether the role of TNC was correctly understood. The question is as follows.

What is the role of TNCs in packet communications? Please select all that apply.

TNCs play multiple roles, and we judged whether the respondents were able to answer all or some of the questions explained in this lecture.

Table 12 Results of question (2)

	Lower grades		Upper grades	
Prior knowledge	No	Yes	No	Yes
Correct	3	0	0	1
Partially correct	6	2	3	9
Incorrect	0	0	0	0

■ Results for Question (3)
This question was designed to check whether the modulation method used for the KOSEN-1 uplink was correctly understood. The answers were evaluated based on whether the correct modulation method had been selected. The questions were as follows.

Which modulation method is used for the uplink of KOSEN-1?

Table 13 Results of question (3)

	Lower grades		Upper grades	
Prior knowledge	No	Yes	No	Yes
Correct	6	0	2	6
Incorrect	3	2	1	4

■ Result of Question (4)
This question was designed to verify whether the modulation method used for the downlink of KOSEN-1 was correctly understood. The answers were judged based on whether the correct modulation method had been selected. The questions were as follows.

Which modulation method is used for downlinking the mission data in KOSEN-1? Please answer all questions.

KOSEN-1 uses several modulation schemes for the downlinks. For the students who answered only "CW," rather than "GMSK" or "AFSK", we considered their answers to be incorrect.

Table 14 Results of question (4)

	Lower grades		Upper grades	
Prior knowledge	No	Yes	No	Yes
Correct	9	1	2	9
Incorrect	0	1	1	1

4. Discussion and Evaluation

As can be observed from the results of the questionnaire, communication tutorials were able to promote understanding among almost all students, even those in the lower grades. As shown in Table 9, all students answered that the tutorial was "somewhat informative" or "very informative. In the post-lecture comprehension check, almost all students correctly answered questions related to communication engineering (modulation and demodulation). In addition, many respondents answered that they were able to understand the communication method of KOSEN-1, switching of operation modes, and the principles of TNC relatively well. Conversely, the evaluation of communication programming was slightly lower than that of the communication tutorial, as shown in Table 10. In addition, although some demonstrations were conducted using actual devices, the demonstrations were focused on the console operation of the Raspberry Pi. Therefore, the fact that the demonstrations could not be understood without an understanding of how to use the Linux command line may have been a contributing factor. Looking at the results by grade level and prior knowledge, there were no significant differences in the final confirmation of understanding; however, as shown in Tables 5 and 6, there were differences in the new knowledge gained. The younger students selected more basic items, whereas the older students selected more applied items. This may be because the younger students had insufficient prior knowledge to understand the basic items and thus did not understand the applied items, whereas the older students had already learned the basic items.

When asked if they could perform the demonstration on their own, many students answered: "yes, I can perform only a part of the demonstration," as shown in Table 7. Many students answered that they could not understand the last part of the demonstration (when a control command was uplinked from the ground station, the satellite OBC interpreted the command, executed the mission, and downlinked the result). Many students answered that they did not understand the contents of the final demonstration.

However, because many students were able to understand the demonstration of the use of each component, each school was required to practice the contents of each component first, followed by further demonstrations and hands-on classes.

Because this lecture was conducted online from the viewpoint of infection control, participants were not able to participate in each experiment. Therefore, it is necessary to establish an environment that facilitates a question-and-answer session and supports the construction of the experimental environment so that participants can further deepen their understanding of the content of this lecture in the future.

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Automatic Mapping of Syntax Trees and Eye Movement for Semantic-based Program Comprehension Pattern Extraction

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Abstract

Understanding how efficient developers understand source code is an important study to improve the work and/or learning efficiency. Many studies have measured developers' eye movement to source code for understanding efficient reading methods. To understand the efficient reading method, researchers must comprehend the corresponding between eye movement and displayed source code. However, it is time-consuming to extract each understanding method/pattern among different source codes, because of the difference in control flow and formats. In this paper, the authors propose a method that converts the eye movement recorded as display coordinates to a semantic transition sequence based on a syntax tree.

Keywords: *programming education, program comprehension, eye tracking, pattern mining, knowledge extraction*

Introduction

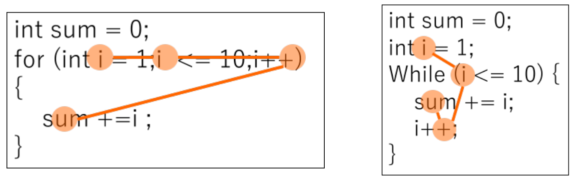
In software engineering research, understanding the “understanding process” during program reading is an important study to teach beginners the efficient reading methodology. The better understanding method improves the efficiency of development processes such as implementation and debug/testing and reduces development costs. A lot of previous research measures developers’ eye movement to analyze the program reading (program comprehension) process (Hauser et al., 2020; Rodeghero et al., 2014; Crosby and Stelovsky, 1990; Bertram et al., 2020). In such research, eye movement is recorded as a time series of positional information by eye tracker and expressed as coordinates of the display. For this reason, some previous research analyzes developers’ comprehension process based on their positional eye movement during source code reading (Hauser et al., 2020; Rodeghero et al., 2014; Crosby and Stelovsky, 1990; Bertram et al., 2020).

However, the position-based analysis of eye movement during program comprehension is a time-consuming analysis because researchers manually understand the correspondence between eye coordinates and source code. Analyzing more general understanding patterns is harder because different source codes have different control flows and formats. Table 1 shows an example of the data recorded by an eye tracker. X and Y mean two-dimensional coordinates that the participant “read” at each time. Previous studies used the position-based eye movement information and analyzed the developer’s characteristics from the direction of eye movement and fixation time (the amount of time the gaze remains within a certain range). For example, Hauser et al. (2020) and Busjahn et al. (2015) found that skilled users tend to move their eyes up and down more than novices.

On the other hand, two source codes with the same control flow but different syntax, and eye movements are different even though the reviewer read the same control flow is the same (Figure 1). In the figure, circle and line mean the series of eye movements, each circle shows the fixation. Two code snippets in the figure calculate the summation from 1 to 10, the (a) uses a for statement and the (b) uses a while statement. These two statements have different structures, hence coordinate-based analysis appears the eye movements for two source codes differently, such as “left to right” at for statement and ”up to down” at while statement. Previous studies manually

Table1. Eye movements as display coordinates

Time	X	Y
24:54.1	322	457
24:54.1	322	458
24:54.2	328	463
24:54.2	326	469
24:54.2	320	479



(a) for statement (b) while statement

Fig1. Two code snippets with different statement

interpret these different eye movements to come from the same understanding pattern, the interpretation needs a lot of time to find.

In this paper, the authors propose an analysis method that converts coordinate-based eye movement to transitions for syntax node in source code. The proposed method abstracts differences in coordinates and statements by representing eye movement as transitions between semantic units in source code. Figure 1 shows two different eye movements onto two source codes, both source codes calculate the summation from 1 to 10. In the figure, eye movement for (a) and (b) follows the same processes, initialization, condition, increment, and result calculation. The simple coordinate-based analysis describes these eye movements as different movements. Our proposed method extracts an ordered list of syntax nodes that eye movement passed. The method allows us to use pattern mining techniques for extracting a general understanding strategy from eye movement data. In this paper, the authors use syntax nodes to represent the smallest unit of processing content (token) that eye movement passed. More abstract representation of eye movement is an important future work for efficient large-scale analysis.

Related Works

Eye-tracking is well used to analyze differences between novice and expert programmers. The state in which the gaze remains within a certain range for a certain time is called fixation, and its central coordinates are called the fixation point. Fixation points are used to identify the location of the reader's interest and its change over time. Hauser et al. compared the differences in the gaze-to-stop point between novices and experts. Hauser et al. (2020). The results showed that the expert group tended to read source code in a nonlinear manner while the novice group read linearly.

Area of interest (AOI) is another well-used analysis method. The researcher defines multiple AOIs on the object (picture or source code snippet), then successive fixations within the same AOI are summarized. Several program comprehension research analyzes developers' comprehension patterns by defining AOIs on the words and phrases in source code (Rodeghero et al., 2014; Crosby and Stelovsky, 1990; Bertram et al., 2020; Chandrika et al., 2017). Rodeghero et al. (2014) analyzed the length of fixation time for AOIs assigned to method signatures, method calls, control flow, and others. The analysis showed that programmers read method signatures much longer time than (method calls) and control flow. Crosby et al. analyzed the difference in review time allocation for each AOIs between novices and experts. The result showed that the experts spent less time on comments than novices (Crosby and Stelovsky, 1990). Peitek et al. (2020) converted coordinate-wise eye tracking data to line-wise for comparison between novice and intermediate students. The results showed that intermediate students moved their gaze to the top line of the source code more frequently than novice students.

Most previous research converted coordinate-based eye tracking data to AOI-based or line-based by manually determining which area in the source code is the AOI/line of code. This conversion requires a lot of time for longer source code. One of the open-source software, iTrace automatically converts the coordinate-based eye tracking data into the line/column numbers in source code. iTrace is implemented as a plugin of Eclipse, one of the commonly used in development and education. The authors use iTrace to convert coordinate-based eye tracking data to line/column numbers of source code. Our proposed method extracts words/characters of the source code from the line/column numbers, then make corresponds with syntax tree.

Proposed Method

Our proposed method outputs eye movement as a transition of syntax node in the source code. Figure 2 shows an overview of our method. In the figure, each square represents software and hardware module, each thin arrow represents information flow. The developer's eye movement during the code reading is measured using an **Eye Tracker**. The Eye Tracker outputs eye movement as a time-series display coordinate (such as X:121, Y:313) with observed time. **Coordinate Line/Column Converter** receives the coordinate-based eye movement and the source code as inputs, then outputs the line/column-based eye movement (Main.java, L:1, Row:13). We used iTrace as the Coordinate Line/Column Converter. Source code is also sent to **Java Parser** to extract Syntax Tree from the source code. Our implementation used ANTLR Java parser, an open-source parser generator. **Syntax Tree/Eye Linker** receives the syntax tree of the source code and line/column-based eye movement, and outputs syntax-node-based eye movement. Java Parser performs lexical and syntactic analysis, and Syntax Tree/Eye Linker converts eye movements to word units in the source code by mapping lexical analysis results to line/column-based eye movements. Furthermore, eye movement is expressed in node units on the syntax tree by mapping the parse results.

Figure 3 shows an example of the syntax tree, that is generated from the main method of source code in Figure 4. In Figure 3, each leaf node denotes words in the source code and its Line/Column numbers. Each internal node describes a syntax structure of child nodes. For example, the right most internal node (block @19) describes that formed from three words (sum, +=, i) at Line 5 in Figure 4, and is a part of for statement (statement @13) at Line 4. The proposed method systematically converts each fixation into the meaning of a word in the source code, the output can use for different analyses with minimal post-processing.

Case Study

In this section, we describe how the proposed method can be used to analyze the developer's eye movement. We select Main.java in Figure 4 and eye movement for

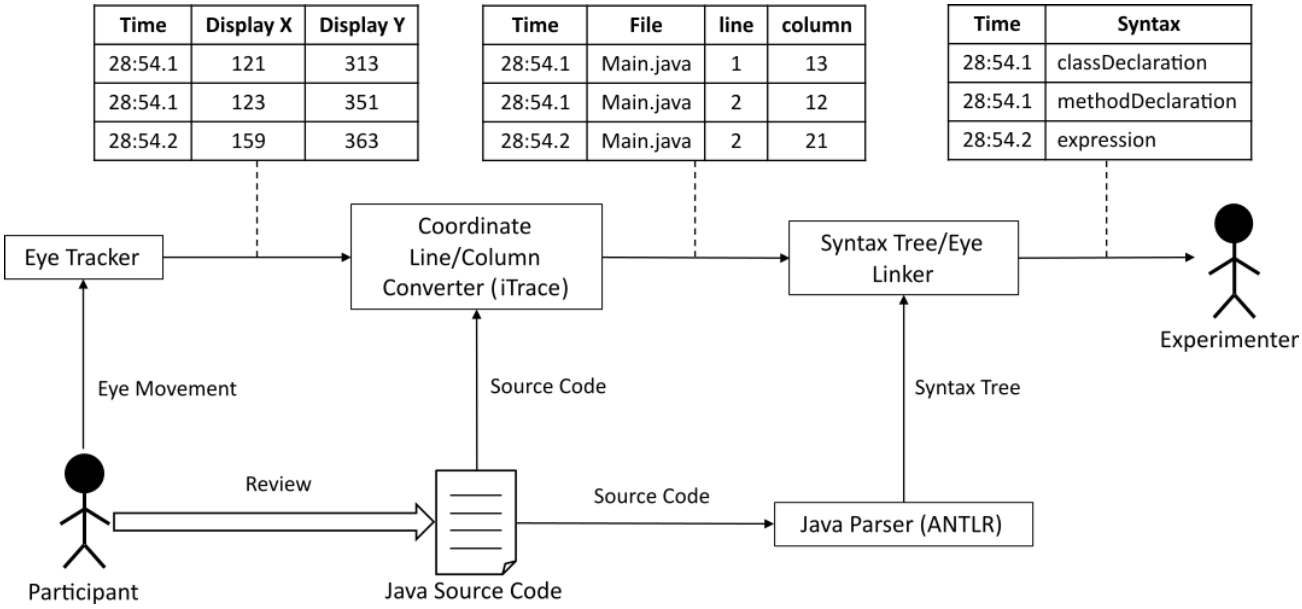


Fig2. Proposed Method

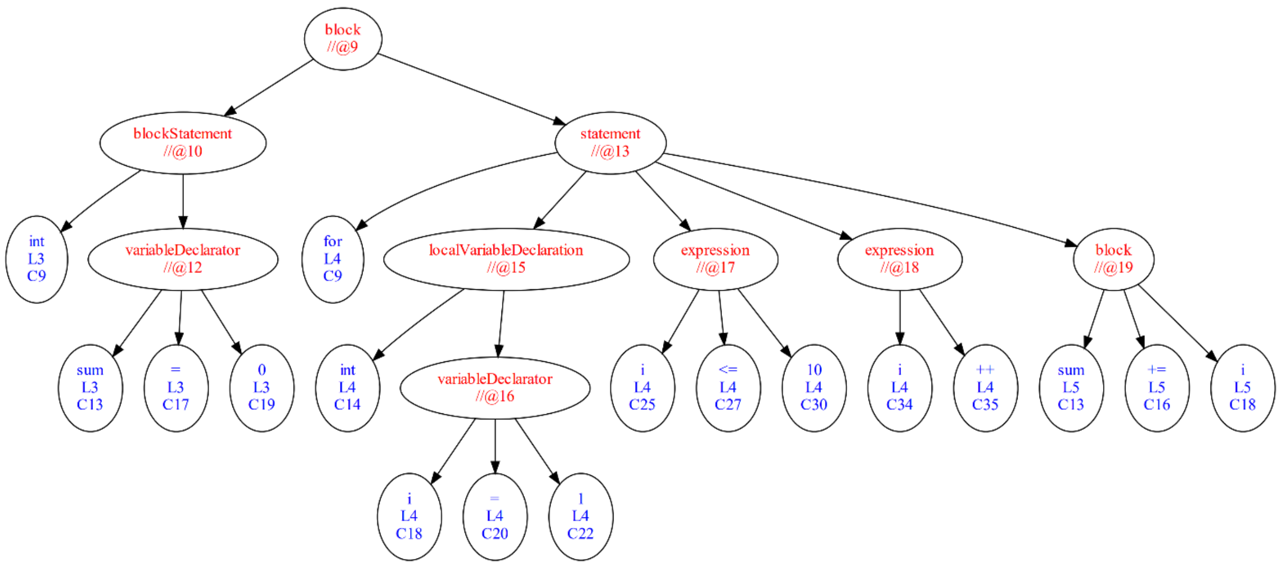


Fig3. An Example of Syntax Tree

the source code for our case study. Figure 5 shows the eye movement visualization by our implementation system, and Table 2 shows an output of the implementation of the proposed method. **Syntax Tree** column shows text form expression of syntax tree for each token. Visualized coordinate-based eye movement in Figure 5 clearly shows the participant read the index declaration, conditional expression, index incrementation, and line 5 in this order. That is the participants may try to understand a process in the "for" statement or a role of variable i. Line/column number and token in Table 2 describe the same eye movement, however it is hard to understand what syntax structure is

```
01 public class Main {
02     public static void main(String[] args) {
03         int sum = 0;
04         for (int i = 1; i <= 10; i++) {
05             sum+=i;
06         }
07         System.out.println(sum);
08     }
09 }
```

Fig4. Main.java

read by the participant without the source code. Compared to these previous eye movement descriptions, the text form syntax tree includes the structure information with different granularities. Hence the proposed method allows for researchers following analysis:

- **Summarization by syntax structure**
  Every syntax tree text in Table 2 includes "blc@9/ stm@13", which means the entire eye movement concentrated on the "for" block in lines 4-6. Each number describes a unique identifier of syntax structure such as class, method, block, and statement, hence consecutive eye movements that have the same ID can combine as one long-time fixation.

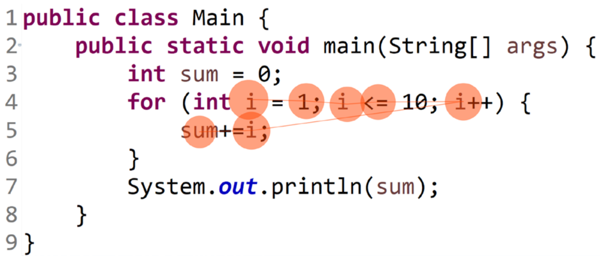


Fig5. Eye Movement for Main.java

- **Abstracted sequential analysis**
  Figure 6 shows the same eye movement in Figure 5, however, is written at the syntax tree in Figure 3. A thin dotted line shows an order of tokens in which eye movements were fixated. Researchers can find the order from line/column-based eye movement, in this case, we can find the eye movement follows variable i in the "for" statement. A thick dotted line in Figure 6 shows an abstracted eye movement. The eye movement follows index declaration (VariableDeclaration@16), conditional expression (conditional expression@17), index increment (expression@18), and the statement in for block (block@19), in that order. Table 2 also shows the syntax tree text includes these IDs and tokens; researchers can select abstraction level that research purpose requires.

- **Pattern mining of vectorized syntax structure**
  The syntax tree text includes different abstraction levels of token information that eye movements stayed. Our proposed method outputs the text

Table2. An Output Example of the Proposed Method

#	Time	Fixation	Line	Column	Token	Syntax Tree
1	02:15	705, 226	4	18	i	blc@9/ stm@13/ lvdec@15/ vdec@16/ i[L4,C18]
2	02:16	800, 235	4	22	1	blc@9/ stm@13/ lvdec@15/ vdec@16/ 1[L4,C22]
3	02:18	877, 234	4	25	i	blc@9/ stm@13/ exp@17/ i[L4,C25]
4	02:19	928, 228	4	27	<=	blc@9/ stm@13/ exp@17/ <=[L4,C27]
5	02:21	1076, 237	4	34	i	blc@9/ stm@13/ exp@18/ i[L4,C34]
6	02:23	708, 283	5	18	i	blc@9/ stm@13/ blc@19/ i[L5,C18]
7	02:24	618, 282	5	13	sum	blc@9/ stm@13/ blc@19/ sum[L5,C13]

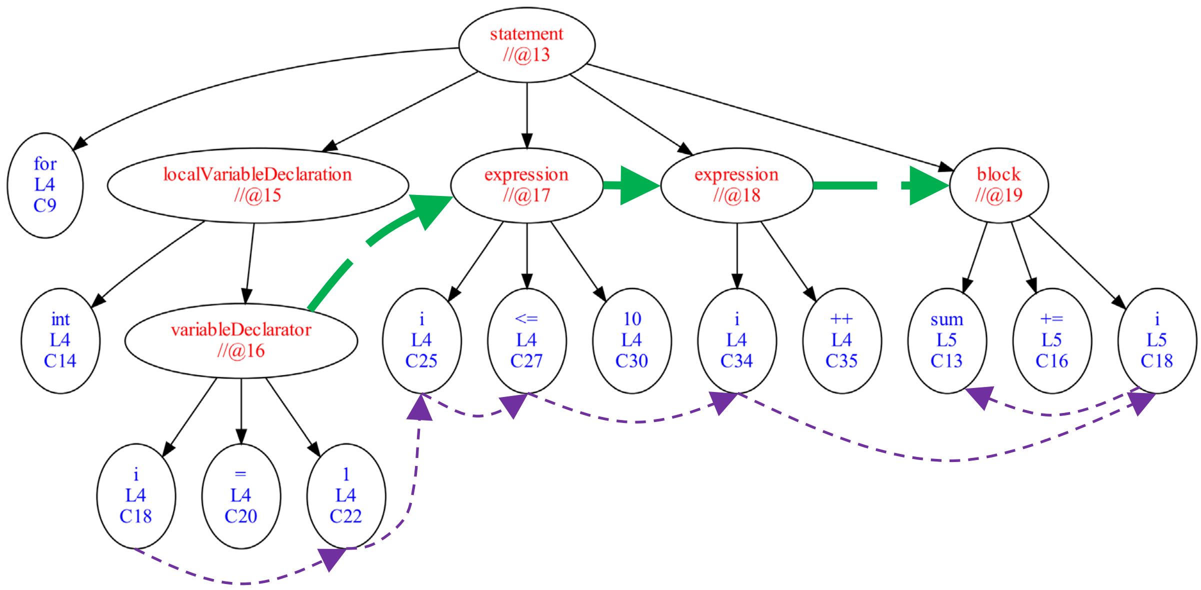


Fig6. An Eye Movement Visualization with Syntax Tree

pautomatically without any pre-analysis or preparation such as AOI definitions. Hence the pattern mining analysis of vectorized eye movement information from syntax trees will provide important data to analyze their reading pattern or method.

- **Inter-source code comparison and mining**
  Different source codes may use different identifiers for the same purpose, such as “sum” and “total” for a variable that contains a total number of calculations. Text-based pattern mining cannot find patterns that contain different identifiers with the same purpose/usage. Also, coordinate-based eye movement cannot find such patterns because the positional relationship of tokens is different between source codes, even if the two identifiers are used for the same purpose. On the other hand, abstracted, and vectorized syntax structures from syntax tree text can extract such patterns.

Conclusion

In this paper, the authors proposed an analysis method that converts coordinate-based eye movement to transitions for syntax nodes in source code. The proposed method abstracts differences in coordinates and statements by representing eye movement as transitions between nodes in a syntax tree. Our case study showed that the text form syntax tree is useful to summarize consecutive eye movements and abstract the eye movement position from token to a statement or a block.

Future work of this study includes the following analyses using the proposed method.

- Extract common understanding patterns from developers’ eye movement
- Efficiency and effect analysis of eye movement patterns including comparison between experts and novices
- Pattern mining of eye movements to different source codes

Acknowledgments

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A REPORT ON THE INITIAL-YEAR PRACTICE IN PORTFOLIO EDUCATION

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Abstract

Portfolio education is very important not only in developing students' ability to learn, but also in improving course content and assuring the quality of education. National Institute of Technology, Sendai KOSEN, Hirose Campus started portfolio education in 2021. The initial year's implementation included the development and implementation of a learning portfolio that utilizes the initiatives and features of this campus. The implementation of a spontaneous growth cycle for students using an objective assessment method of generic skills and the involvement of parents as mentors in off-campus life were introduced into the portfolio.

This paper will introduce the implementation of the initial year at the Hirose campus, as well as the planned development of the portfolio for the following year and beyond.

Keywords: *learning portfolio, generic skills, a spontaneous growth cycle for students, Parental Involvement*

Introduction

It is said that the results of an examination to check knowledge retention are not sufficient to explain what students have substantially learned. It is very important to create a learning portfolio that summarizes the learning process and outcomes, such as what students learned, how they learned it, and how they applied what they learned. In addition, as shown in Fig. 1, students' own reflection on the learning process and improvement practices using the learning portfolio have led to improved learning and independent study [1]. On the other hand, it is said that teachers can improve their lessons by reflecting on their own lessons and designing lessons from the students' perspective through the creation of teaching portfolios [2]. Furthermore, the organic combination of learning portfolios for students and teaching portfolios for faculties will enable more effective lesson improvement [3]. Effective use of the information in these portfolios throughout the whole school will lead to improvement of the overall curriculum and substantiation of the policies of academic/ curriculum/diploma.

In Japan, however, educational practices utilizing career passports and portfolios are being promoted at all educational institutions, but have only just begun. In order to realize and establish quality assurance of education in 2020, the National Institute of Technology (KOSEN) has set six priority items [4], one of which is the use of portfolios, and is supporting and strengthening the efforts of each college of KOSEN. At Sendai KOSEN, Hirose Campus, student-centered portfolio education has been implemented since the academic year of 2021, based on the educational improvements focusing on generic skills promoted since 2014. This paper presents a case study of the initial year of portfolio education conducted at the Hirose Campus for the students who are new to portfolios, capitalizing on the strengths and features of the Hirose Campus.

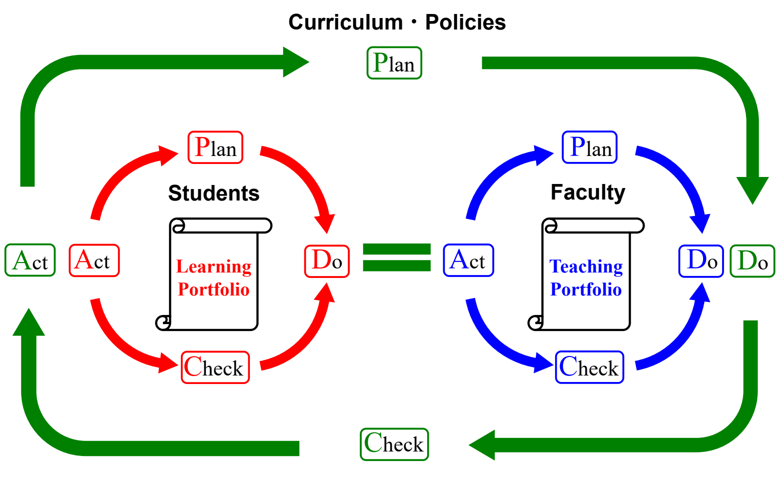


Fig. 1. Overview of Hirose Campus' Approach to Portfolio Education

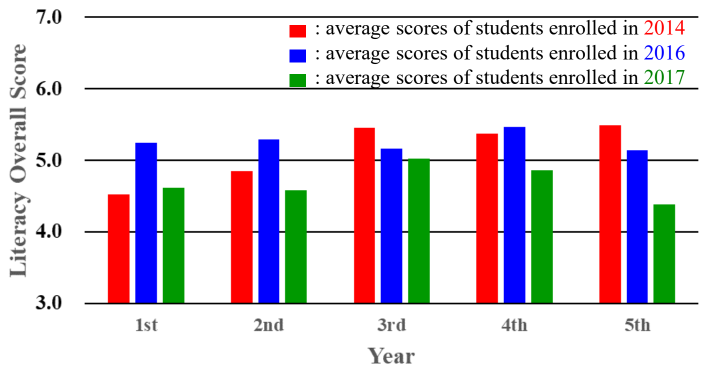
Strengths and Features of Hirose Campus in Portfolio Education

In implementing portfolio education, we decided to start with a simplified learning portfolio with as little burden as possible, taking into consideration students who are dealing with portfolios for the first time. In developing the portfolio, we also had in mind the development of a portfolio that would take advantage of the campus' initiatives and features.

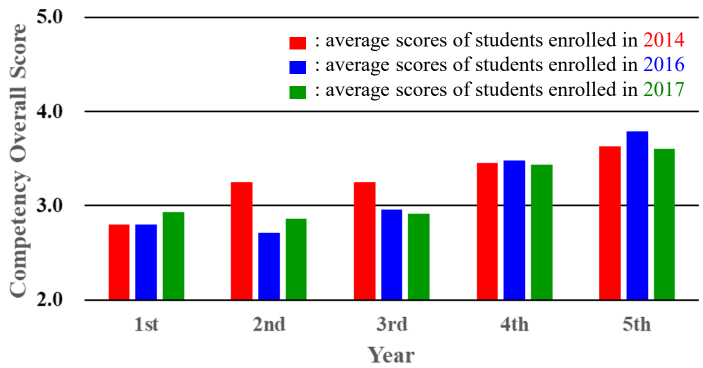
First, our campus conducts an annual survey of students' generic skills using an external test to develop their generic skills. The external test adopted in the survey is a standardized test called PROG [5], which is an objective evaluation method. As an example of the survey results, Figure 2 shows the tracking results of grade-level average scores for literacy overall and competency overall for students enrolling in 2014, 2016, and 2017. Both literacy and competency scores have been observed to grow as our students progress through the school year. With regard to literacy, however, a saturation trend is observed above a score of 5.0. (There is a decrease in the fifth-year literacy scores for students enrolled in 2017. This is due to the fact that some students did not take the exam seriously; if we exclude the scores of students who completed the 40-minute exam in less than 15 minutes, we obtain a mean of 5.14, which is the same trend as other entering-year students.) By analyzing these survey results using class and grade level averages, we use them to improve our campus curriculum and lesson contents [6].

These results of generic skills surveys are highly compatible with portfolios by dealing with individual student scores. On the other hand, it is difficult for students themselves to correctly assess their own level of generic skills, and it is beneficial to assess them with an objective external test. In addition, the use of external tests will allow the students to compare their scores with scores from schools other than their own. These advantages will lead to a spontaneous growth cycle in the development of generic skills, as students will be able to accurately assess their position and reflect correctly.

Second, KOSEN is a school that deals with students at a younger age than universities, between 16 and 20 years old. In the Hirose Campus, on the other hand, almost 80% of students are commuting from their parents' homes to the campus and they have many contacts with their parents outside of school. Therefore, we wondered if the portfolio could be shared between parents and teachers, and if parents could serve as mentors outside of school life. Through the portfolio, we believed that it was possible to build a collaborative student support system between parents and teachers.



(a) Literacy overall score



(b) Competency overall score

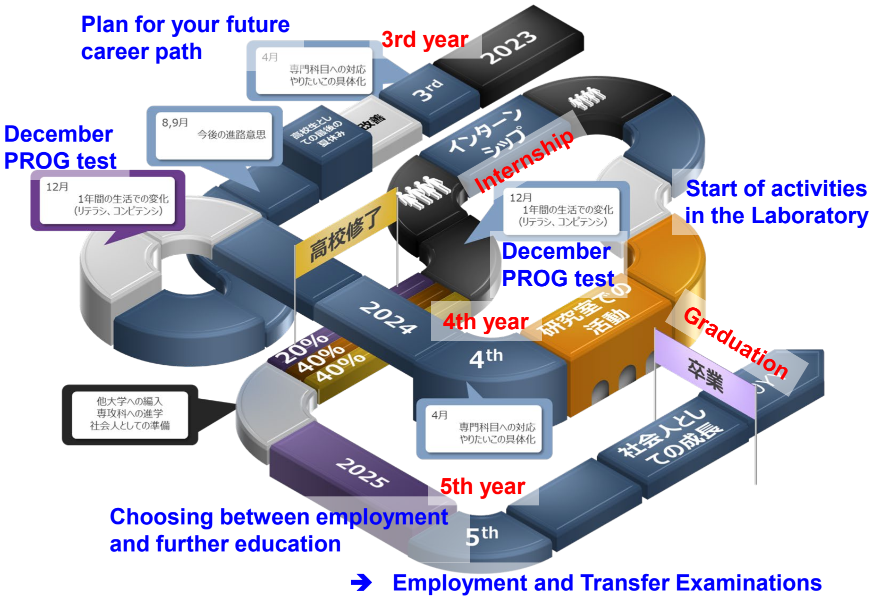
Fig. 2 Yearly changes of overall scores of Literacy and Competency parts for the follow-up survey of the same students

Initial Approaches and the Portfolio developed

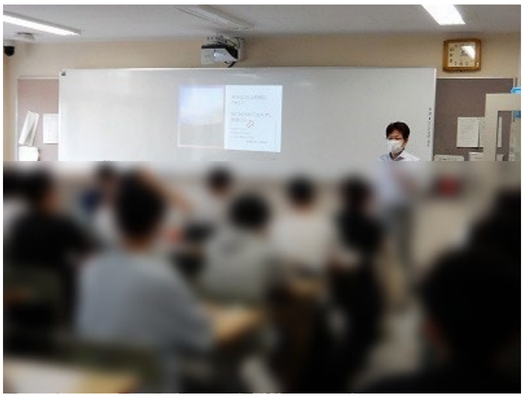
In order to ensure that the portfolio is not merely a formality for students who are using it for the first time, several innovations and attempts have been made, which are described below.

First, paper portfolios were introduced to reduce the burden on students at the start of their portfolios. The contents of the portfolio were made easier to understand, and the faculty did not specify all the items to be included, allowing students to freely write anything they wanted. Furthermore, in order to achieve full individualization in the future, items can be added freely according to students' individual objectives.

Second, we provided regular guidance and portfolio-filling workshop to help students understand the meaning, intent, and use of portfolios. As an example, the content of the first guidance session and the workshop scene conducted for first-year students are shown in Fig. 3. The guidance shown in Fig. 3 (a) explained the schedule from admission to graduation and made students aware of the timing of important events (timing of choice) until graduation, such as course selection and laboratory assignment. At each time of choice, the



(a) the content of the guidance



(b) the scene of the guidance

(c) Video Content

Fig. 3. Guidance and workshops

necessary preparations to achieve their objectives were explained. In the second guidance session, the Career Support Office provided guidance on career activities, explaining the importance of preparation from the first year and effective use of portfolios with an eye toward employment.

Third, as for generic skills which are difficult for students to recognize by themselves, we decided to use a portfolio to review, improve, and set goals based on objective evaluation results using the PROG results conducted once a year instead of relying on self-evaluation. In the workshop, we explained the characteristics of our generic skill development at our campus and had the students work individually on self-analysis and goal setting using their own PROG scores. Fig. 3 (b) shows the scene of workshop.

Finally, we have made videos of the guidance and workshops available for viewing and checking at any time so that students can fill out their portfolios anytime, anywhere. An image of the video content is shown in Fig. 3 (c). The video content is individualized for each grade level, highlighting the key areas of importance at each grade level.

Fig. 4 shows part of the generic skills development part as an example of the portfolio developed. Students are able to intuitively recognize their own growth by entering the results of the PROG test, which they take once a year, on a graph in their portfolios. Students then compare their scores to the class average and average of university students to correctly identify their own generic skill level. By recognizing their own level of growth, reflecting on the reasons why they did/did not grow, and considering ways to improve, the students themselves spontaneously turn the cycle of growth around.

In addition to the generic skills development part, the developed portfolio consists of a part that record of learning history, extracurricular activities, and qualifications, as well as a record of short- and long-term goals. A parental comments section is placed in the

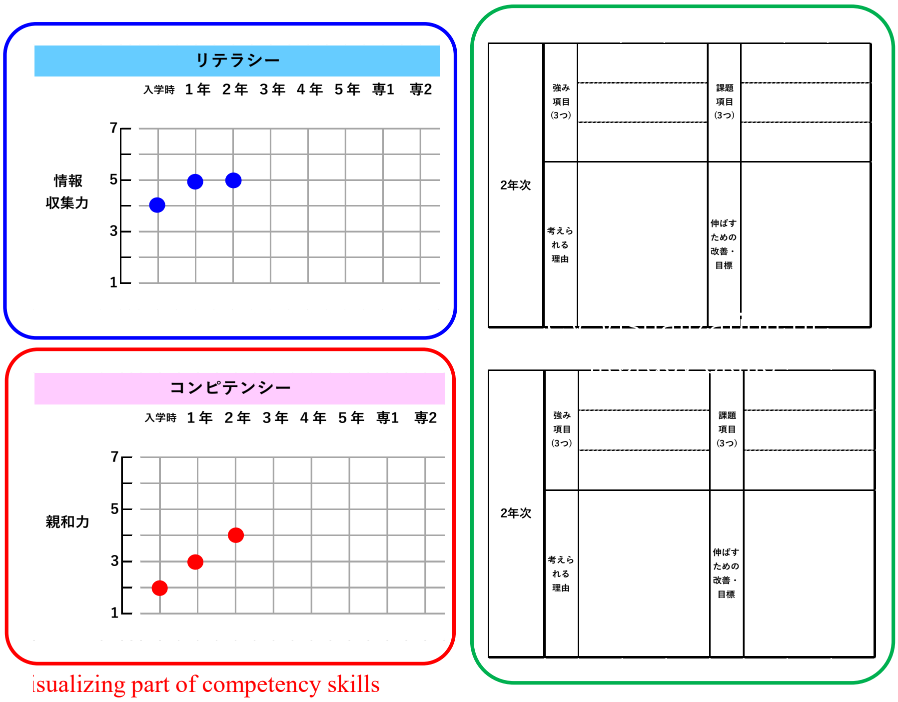


Fig. 4. A part of the portfolio that we developed.

record part to record mentoring advice to parents. In addition, there is an open-ended section that students can use for their own purposes.

At this point in time, the learning portfolio developed is a very simplified one. In the future, as students' understanding of the portfolio permeates, we plan to add a reflection part on learning as follows; why did you study the subject, what have you learned from it, and how does what you have acquired relate to your future goals, and so on. In parallel, we plan to digitize the portfolio, add a showcase portfolio, and examine effective ways to reach out to parents.

Future Development of Portfolio Education

For the initial year of portfolio education, we completed the development of the basic portion of the student learning portfolio using an objective assessment of generic skills. Improvements to the Learning Portfolio are described in the previous chapter.

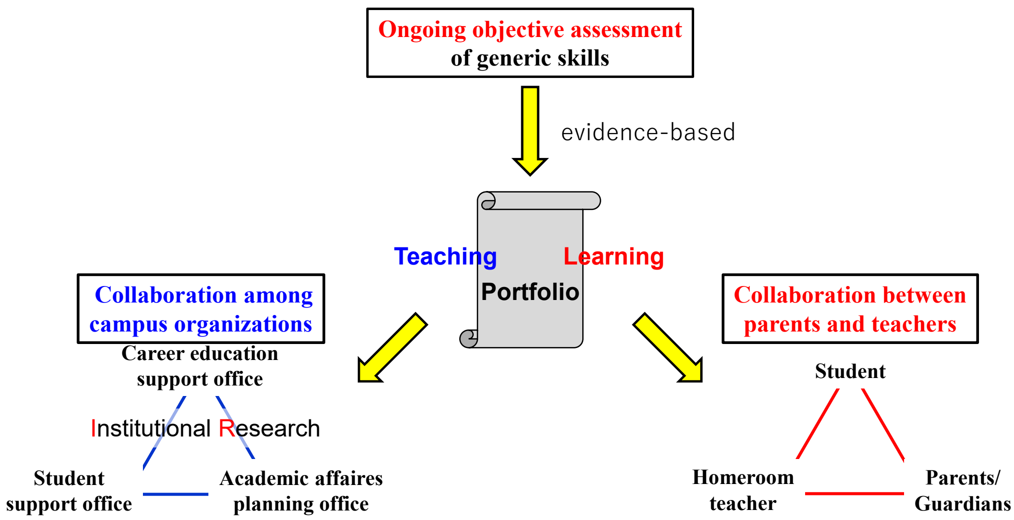


Fig. 5. A conceptual diagram of the overall portfolio education

Fig. 5 shows a conceptual diagram of the overall portfolio education that we aim to implement in the future. First, a teaching portfolio will be developed, as well as student learning portfolios, and then faculty members will create them for all subjects. In order to effectively implement teaching portfolios, we plan to conduct teacher training on the importance and necessity of portfolio education and workshops for teachers on the use of portfolios. By creating a teaching portfolio, teachers can reflect on their teaching methods and improve their teaching skills individually. On the other hand, the school organization will articulate effective teaching methods by linking information from both Learning and Teaching portfolios and analyzing IR. The findings obtained will be shared with faculty members to further improve lessons.

Furthermore, the information obtained from the portfolio will be used by the Academic Affairs Planning Office, the Student Support Office, and the Career Education Support Office to improve the curriculum and provide more effective support for students. The goals and ideas from the students' and faculty members' perspectives will be consolidated, and by analyzing and utilizing the data, we will be able to improve classes, assure the quality of education, and set policies that are in line with reality.

Conclusions

National Institute of Technology, Sendai KOSEN, Hirose Campus started portfolio education in 2021. The initial year's implementation included the development and implementation of a learning portfolio that utilizes the initiatives and features of this campus. The implementation of a spontaneous growth cycle for students using an objective assessment method of generic skills and the involvement of parents as mentors in off-campus life were introduced into the portfolio. As part of the initial year of education, support was provided for portfolio beginners by offering guidance and workshops for students on portfolio use. In addition, by distributing the guidance and workshop content as video content, students can fill out their portfolios and check the content anytime, anywhere.

The initial year learning portfolio developed is a very simplified version. In the future, we plan to develop a digital, showcase-type portfolio, as well as enhance our content. As the school organization, we will also develop and implement teaching portfolios by teachers. Data from both learning and teaching portfolios will be used to improve lesson contents and curriculum more effectively.

Acknowledgements

In implementing this project, we have gained the cooperation of the homeroom teachers and many other staff members at our campus. We would like to express our heartfelt gratitude for their generous cooperation and support.

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INVESTIGATING THE EFFECTIVENESS OF TEAM-BASED LEARNING IN COMBINATION WITH PROBLEM-BASED LEARNING TO ENHANCE OVERALL LEARNING IN GENETICS

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Abstract

Problem-based learning (PBL) is a pedagogical approach designed to promote learning, critical thinking and problem-solving in authentic learning situations. Team-based learning (TBL) is an innovative teaching and learning pedagogical approach that also incorporates the main elements of constructivist learning. Both are established learner-centric approaches to teaching and learning in which students work in interactive small groups, and use peer-assisted learning to solve complex, authentic, real-world problems. The two pedagogical approaches complement each other and have each been shown to enhance learning in studies conducted. The principles of TBL centre around self-directed learning, team work, problem solving and students receiving feedback – all of which are congruent with the principles of PBL. We believe that the two pedagogical approaches can be used synchronously to enhance students' overall learning.

A mixed-methods study was conducted to examine the effectiveness of using TBL in conjunction with PBL to enhance both learning of concepts and application of concepts in a module teaching the basic concepts of Genetics at Republic Polytechnic. The hybrid TBL-PBL pedagogy was implemented in a total of seven classes that formed the intervention group. Access to all resources was comparable for students in both intervention and control groups. Hallmarks of a hybrid TBL-PBL lesson included - learning content related to the lesson, followed by readiness assurance tests at an individual and team level (iRAT/tRAT). This was followed by application of the concepts related to the lesson to solve real-world problems.

In this study, lecturers found that students experienced increased levels of engagement, interaction and perceived confidence in both their problem-solving and concept learning. They were able to learn concepts well, and then apply them to solving problems effectively. Students enjoyed the classes, felt they were able to learn more effectively in a safe environment and felt that solving problems as a team was an effective way to practice what they have learnt through the day.

Keywords: *Team Based Learning, Problem Based Learning, Hybrid, Constructivist Learning, Genetics*

Introduction

Learning is commonly described as a process resulting in a relatively permanent change in the mental processing, emotional functioning, and/or behaviour. It is a dynamic process by which individuals acquire new knowledge or skills and alter their thoughts, feelings, attitudes, and actions. Genetics is a field of study, where the scientific bases of genes and heredity are explored. In this module, at Republic Polytechnic, our students are required to explore and understand the rules and concepts related to inheritance and heredity, and to apply them to various scenarios, including case-studies and real-world problems. As with many other fields of study in science, students are often required to first learn the "rules" but, are considered proficient in the subject only when they are able to apply the concepts that they have learnt. For example, students would learn about Mendel's Laws of Inheritance, and how they apply to human diseases, plant biology and even in genetic counselling.

At our institute, the primary instructional strategy used in the module Genetics was Problem Based Learning. Problem-based learning (PBL) is a pedagogical approach designed to promote critical thinking and problem-solving in authentic learning situations. PBL enables students to learn concepts while simultaneously engaging actively with meaningful problems. Students are given opportunities to problem-solve in a collaborative setting, and to form self-directed learning habits through practice and reflection (Hmelo-Silver, 2004). In the PBL classroom, learning can be considered a "constructive, self-directed, collaborative and contextual" activity (Dolmans, De Grave, & Wolfhagen, 2005). At Republic Polytechnic, our beliefs about effective teaching and learning are primarily built on social-constructivism - learner centric approaches

such as PBL form the core of our teaching and learning practices (Republic Polytechnic, 2019).

Team based learning (TBL) is an innovative teaching and learning pedagogical approach that was developed by Dr. Larry K. Michaelson in the 1970s (Team-Based Learning Collaborative, 2018). It is a student-centred instructional strategy that is firmly grounded within the constructivist theory (Hrynchak & Batty, 2012). It is widely adapted as an instructional approach across many disciplines, especially in disciplines related to medicine and the health sciences (Parmelee & Hudes, 2012). TBL is a specific and intensive form of small group-based learning, where the majority of class time involves students working in strategically formed teams to help one-another learn concepts via a team assignment. Patricia Hrynchak and Helen Batty (Hrynchak & Batty, 2012) proposed that team-based learning incorporates the main elements of constructivist learning, in which the focus is on the "mental representation of information by the learner". They proposed that, in TBL:

1. The Lecturer is a guide to facilitate learning.
2. Learners should encounter inconsistencies between preconceptions and new experiences to provide a basis for development of new understandings.
3. A focus on relevant problems accompanied by group interaction promotes learning.
4. Learning requires reflection.

The Hybrid TBL-PBL Classroom

The key elements of TBL are also important cornerstones of the PBL approach, which makes a hybrid between the two approaches conceivable. A hybrid of TBL and PBL would combine the best, and most important attributes of both approaches – one that incorporates both self-directed and collaborative learning. Both PBL and TBL utilise collaborative learning methods to promote critical thinking and collaborative skills that are vital in a scientific education. Collaborative learning in PBL is most significant in the knowledge building for the students, while in TBL, collaborative learning is vital in the application and knowledge application stage. Importantly, both approaches encourage and drive learners to use problems to build on existing knowledge and apply new knowledge (Dolmans, Michaelsen, Van Merrienboer, & Van Der Vleuten, 2015). Both TBL and PBL rely on constructivist learning theories to engage and motivate students, additionally both models encourage active and participatory learning though problem solving, critical reflection and guidance from a facilitator. Additionally, in both approaches, a safe learning environment is essential, in which students are provided with opportunities to create their own chaos, challenge concepts and develop their understanding. Key differences between the two approaches are centred around the flow of the learning – mainly in terms of preparation requirements and class structure. (Burgess, Roberts, Ayton, & Mellis, 2018).

Like Burges and Roberts *et al* (Burgess, Roberts, Ayton, & Mellis, 2018) and Dolmans and Merrienboer *et al* (Dolmans, Michaelsen, Van Merrienboer, & Van Der Vleuten, 2015), we believe that an instructional strategy that poaches and combines the most applicable aspects of both PBL and TBL would help to enhance overall learning outcomes for our students.

Students at our institute come from varying educational and socio-economic backgrounds - levels of engagement and prior knowledge may vary within a classroom, as might the opportunities for pre-class preparation. The authors V.M D'souza and J.H. Shah have been teaching Genetics for over eight years. In our experience, students often find it challenging to apply the concepts to different scenarios while they are being learned, hence we believed that they may benefit from this hybrid classroom. Additionally, since both of these instructional strategies have been extensively explored in healthcare related domains due to the emphasis on knowledge acquisition and application of concepts, it is believed that its implementation in a module such as Genetics would be effective and insightful.

In this paper, we will examine the changes in effectiveness of learning Genetics by implementing variations to the teaching approach and pedagogy by leveraging on both TBL and PBL.

Methods and Pedagogy

Implementing aspects of TBL in a PBL classroom was attempted purposefully, with a focus on maintaining the constructivist learning that is central to both pedagogies. The central task of each lesson was focused on enabling learners to internalise new scientific concepts, and to use the concepts being learnt to analyse and solve authentic, complex problems. Care was taken to ensure that lessons were designed based on the established learning objectives for the module, and there was no perceived or real loss of content between the control and the intervention groups. In this study, seven classes across four diplomas from the School of Applied Science were randomly selected for learning via the hybrid TBL – PBL instructional strategy – this formed the "Intervention" group. There were 166 students in this group. The remaining classes were conducted via the *in situ* PBL approach and formed the "control" group (n=174). As is usual in Republic Polytechnic, each class comprised of 22-25 students arranged in teams of 4 - 5 students. The module consists of 13 lessons, of which 8 were included in the study. Lecturers within the module team are all domain experts and experienced facilitators. The module team was also divided in two, one group to teach the intervention group and one to teach the control group. This was done with the aim of reducing potential obscuring of teaching strategies in each classroom.

A few of the key considerations when designing the lessons included:

1. A carefully crafted problem that would help to challenge students and to reveal common student misconceptions.
2. Teams were carefully chosen following the principles suggested in TBL guides (Team-Based Learning Collaborative, 2018) (Farland, 2013).
3. Collaboration and discussions within and between teams was encouraged in the presence and absence of the lecturer within the classroom.

In the intervention group, students' learning, understanding and readiness for the "application" stage were assessed via the Readiness Assurance Process – a hallmark of the TBL approach. Students completed an individual multiple-choice quiz based on concepts learnt during the completed portion of the lesson - this is the individual readiness assurance test (iRAT). Each student received 15 questions from a question bank of 25. Following the individual quiz, a set of quiz questions from the same question bank were re-administered for the students to work on within their teams – this is the team readiness assurance test (tRAT). Teams were to indicate their answers on the test card known as an IF-AT (Immediate feedback assessment technique) (Team-Based Learning Collaborative, 2018), which resembles a scratch-and-win type of testing card. The greater the number of attempts made before a correct answer is arrived at by the team, the less points the team will receive for that question. Students would receive their individual marks and team points promptly after completion of each test. Following the team quiz, the teams were encouraged to appeal and defend their answers and discuss with the entire class to clarify any ambiguities of concepts or understanding. Once this process was completed, the learners moved on to the problem-solving phase where students were given real-life case studies and scenarios to discuss and solve. As per the requirements of both PBL and TBL - several opportunities for self-assessment, reflection and feedback were ensured.

Lessons in the *in situ* PBL classrooms followed a structure commonly used at Republic Polytechnic. In the first learning phase, students are introduced to the problem, and encouraged to activate prior knowledge and to explore. In the second, learning of concepts is scaffolded and knowledge gain is ascertained via discussions. In the third learning phase, students present their solutions to the problem, and showcase their learning via presentations or critique.

Figures 1 and 2 summarise the class structure for the control (Figure 1) and the intervention (Figure 2) groups.

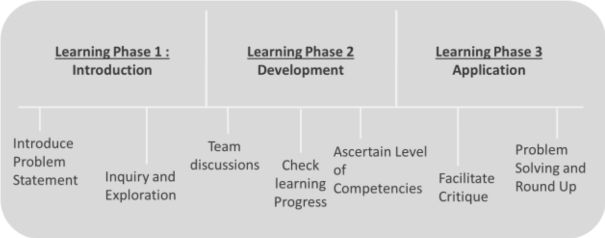

Figure 1: Lesson structure and flow in a PBL classroom

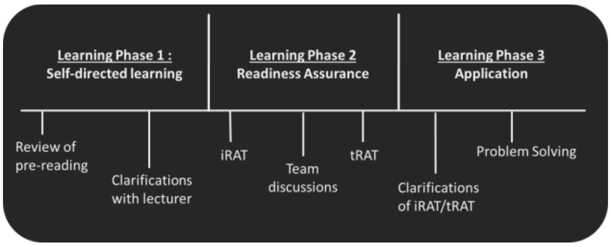

Figure 2: Lesson structure and flow in a hybrid TBL-PBL classroom.

In the course of the semester, data related to student learning outcomes (e.g., quiz scores, gaps in learning, problem solving clarity), collaborative learning (e.g. team scores, peer evaluations) and classroom experience (e.g. surveys and focus group discussions) were collated for both the control and the intervention groups. Focus group discussions and experiential feedback were collected from students in both groups as well as from staff in the module team facilitating both the control and the intervention groups.

Results and Discussion

A post-course survey showed that student enjoyment arose from various aspects of the hybrid pedagogical approach. They appeared to especially appreciate aspects that allowed them to separate the concept learning from problem solving. Results showed that 87% of the students in the intervention group enjoyed the classes with the TBL-PBL hybrid approach. Over 80% of them felt that the hybrid approach stimulated their interest in learning and over 70% felt that they had an improved understanding of the content and also felt that they were able to better apply these concepts. 76.9% of the students felt that they were able to better prepare for summative assessments (examinations).

In depth focus group discussions revealed that the experience of a hybrid classroom was positive for both lecturers and students – there was increased enjoyment and interaction as well as reduced stress in most lessons. Students expressed that they were less afraid to speak up and felt that they could "enjoy the discussing and arguing the team, as we all knew the content better, and were not afraid of being wrong". The increased enjoyment was evident in classroom behaviours amongst students, and was also reflected in surveys with both staff and students. This in itself was an advantage in a hybrid classroom and

the effect of enjoyment in classroom learning is well established (Hernik & Jaworska, 2018). The increased enjoyment in class was inevitably inter-linked with increased engagement within the class.

Learning of concepts before the problem solving and discussion components of the class seemed to have an early and consistent impact. There was an increase in the students' confidence and comfort in engaging with the content, which had a knock-on effect on their enjoyment. This was reflected in Focus-Group Discussions with both staff and students. This in turn had a positive influence on the analysis and application portion of the learning for the students. Lecturers found that classrooms were more interactive with students being more engaged in peer learning and team discussions, and that students were able to learn concepts thoroughly. Less prompting was needed from the lecturers for students to engage with each other. Importantly, students were able to apply the concepts learnt to wider and deeper problems - in clear, critical and logical ways what not only challenged them, but also (happily) challenged the lecturers.

As students' enjoyment and engagement increased, so did their speed and agility in problem solving and application of concepts. The complexity of the concepts to be learnt increased as the module progressed, with lessons often requiring deeper connections between old and new knowledge in order to create and apply new ideas and theories. Lecturers found that students in the intervention classes rose to such challenges in a very positive way, they did not often feel overwhelmed. Significantly, it was observed in classroom interactions, reflections and in surveys, that students in the intervention classes were more comfortable with making mistakes during the lesson, as they knew that errors could be rectified during team discussions. It is this aspect of the changes in learning using the hybrid TBL-PBL instructional stratergy that we found especially rewarding. It was observed by lecturers that students were faster and more effective in problem-solving during lessons that were delivered via the hybrid approach - they were able to tackle problem solving with increased effectiveness with passing weeks.

Overall, during the course of the study, and when evaluating the outcomes, the staff and the students made some interesting and even surprising observations regarding both the classroom experience, and the overall learning experience in the module. As lecturers, we noted changes in learning behaviours, speed of learning, depth of application and comfort with content and critical thinking. Learners were more curious and more engaged in arguments that were well researched and evidence based. These learning behaviours are not only vital in most sciences but are the 'holy-grail' in most student centric classrooms. Thus, indications were that this was an intervention that broadly achieved its goals.

In our experience, the hybrid TBL-PBL classroom was able to draw on the best aspects of both pedagogies to create a classroom learning environment that made the best of the constructivist ideals. Students were able to activate prior knowledge, create chaos and learn the content before and during class. The testing process before the application phase of the class was beneficial both to the students and to the lecturer. Learning gaps could be identified and rectified promptly. Due to the increased peer interactions during the t-RAT, lesser lecturer intervention was needed for clarification of concepts; students were able to clarify with each other, however, there was time and opportunity for the lecturer to implement corrective measures if needed. The readiness assurance process being conducted at an individual and a team level not only allowed students to critically assess their own learning, but also allowed them opportunities to obtain immediate feedback, identify gaps in their learning and to fill in any gaps in concept understanding that may have remained. It was also observed that the use of the IF-AT for the t-RAT not only created a focal point for team discussions, but also team enjoyment. Students expressed excitement and joy during the process. In a survey conducted, students mentioned that the "IRAT and TRAT [sic] was fun and a very enriching way to learn!" The confidence gained regarding the learning of the concepts created a good platform for the application and problem-solving phase of the class, where the students were able to use all the knowledge acquired to interact with and solve complex real-world problems logically and critically.

Findings from this study showed that a hybrid TBL-PBL classroom would be able to create a supportive and open student centric atmosphere that enhanced constructivism, self-directed learning, reflection and learning amongst students. The separation of the "concept-understanding" and problem-solving components of the learning created the perception of a supportive classroom, that was linked with the other learning advantages observed in this study. This was also observed by Burgess and Roberts who found that "within TBL, students appreciated the structure whereby an appropriate emphasis was placed on basic science, in order to apply and link this knowledge to the problem solving activity" (Burgess, Roberts, Ayton, & Mellis, 2018). We feel this is of special importance in context of increasing diversity of students in terms of background, abilities and motivation levels. The fact that they feel safe in the classroom, firstly within their team and secondly in their understanding of the concepts before the start of the critical application and problem solving process, increases their engagement, reduces their stress and thereby widens explorative boundaries. Stress reduction is most linked to the learners perception that they are able to reflect on and amend any mistakes or misconceptions that may have surfaced with lesser chance of judgement from others in the class or the intervention by lectures. The significance of this observation is enhanced by comments shared by students during the survey module feedback, reflections and focus-group discussions e.g. "I would appreciate if TBL-PBL is included in all modules because TBL is much better in making the lesson more fun, relax and easier to spot my gaps or mistakes".

In this module, as in most science and healthcare based learning, opportunities for critical reflection are

needed to allow students to make judgements and modifications to their existing knowledge (Mohanna, Cottrell, Wall, & Chambers, 2011) In the hybrid classroom, the sequence of learning appears to ensure that students have ample opportunities to engage with the content, each other and their lecturer to gauge and critique their own understanding – in this aspect our observations and findings were similar to Michaelson, Parmelee et al (Michaelsen, Parmelee, McMahon, & Levine, 2007). The safe learning environment perceived within the classroom, and the opportunities for self-reflection on knowledge seemed to be of special significance to the students who are naturally quiet, shy or unsure of participating in larger or newer learning environments. Inevitably, reflection occurred when they compared their understanding during the team readiness assurance process and the team problem solving process.

We also noted that the changes in the collaborative structure and interactions in the classroom could be linked to improved application of concepts. In a TBL-PBL classroom, there is inevitably knowledge that is gained via communication – be it via discussions or via learning during the readiness assurance tests or problem solving segments of the classroom. Carmichael et al (Carmichael, 2009) examined TBL in biology classes in terms of collaboration and critical thinking. They found increased quantity and improved quality of student engagement in TBL classes and significantly, observed that not only did students learning via TBL achievebetter grades, they were able to respond to exam questions related to data interpretation with more accuracy – implying improved critical thinking skills. While the methodology of their study differed from ours in some significant ways, our observations mirror theirs in terms of enhanced collaboration and engagement in class being correlated to enhanced evidences of critical thinking from the learners – especially when related to concept application and problem solving – which are cornerstones of gaining proficiency in Genetics.

While some gaps in terms of data collection, understanding and experiences remained for both the lecturer and student in the hybrid TBL-PBL classroom, the overall benefits of the learning experience are hard to ignore. Drawing on the best attributes of both pedagogical approaches, TBL-PBL hybrid classrooms can benefit students in the learning of concepts as well as in the application of these concepts to real-world problems. The hybrid classroom was engaging for both lecturers and students, and presents an excellent alternative for a learner centric classroom.

Conclusions

Team Based Learning, on its own or in conjunction with other student centred pedagogies such as PBL is a promising approach to learning, that seems especially suited to students from tertiary institutions preparing for careers in the biological and healthcare disciplines. These students often have differing starting points, but by using student-centric tools, and slightly structured instructional strategies we are better able to prepare them for life-long learning and long careers. Reports consistently associate TBL with improved motivation and learning (Jeno, et al., 2017) opportunities for improved inclusivity (Muheidat & Tawalbeh, 2018) and enhanced critical thinking (Espey, 2016) (Silberman, Carpenter, Takemoto, & Coyne, 2021). As we strive to equip our students with relevant and important skills, it would be beneficial to continue leveraging on the possibilities that TBL has to offer in conjunction with PBL or in other ways possible.

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Integrating In-Demand 21st Century Core Skills in Diploma in Aerospace Electronics Curriculum: A Pilot Run

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Abstract

This paper provides the background to introduce the Common Core Curriculum (CCC) through ten common core modules in the Diploma in Aerospace Electronics (DASE) to ensure that all DASE graduates are equipped with the appropriate suite of critical core skills to thrive in the society and economy of the future. It also covers the revamp of the DASE curriculum in School of Electrical & Electronic Engineering (SEEE) where DASE has been identified as one of the two diploma courses to pilot the CCC in Singapore Polytechnic

The revamp includes the actual integration efforts carried out for the first-year project-based module, Introduction to Engineering (IE), to be implemented alongside with the two relevant common core modules, namely the Collaboration in the Digital Age (CDA) and Effective Writing for the Workplace (EWW) for all first year DASE students in their first semester. The work also covers the planning of teaching schedule to ensure timely introduction of the CDA and EWW modules so that students can see the relevance of the skills and knowledge and apply them in IE. Integrated assessments are also designed to evaluate the learning outcomes of the students taking IE, CDA and EWW.

A total of 87 first-year DASE students took the revamped curriculum and were surveyed on their learning experiences. About 90% of the students responded and the results showed that most of them had a positive learning experience and were able to manage the workload. The teaching team also found values in pairing domain and CCC modules as the students were able to integrate both the knowledge and skills in their assignments as the end products.

This paper concludes with the success of the pilot run for the DASE course. Implementation of the CCC modules will be extended to the remaining three diploma courses that the SEEE also offers.

Keywords: *critical core skills, 21st century competencies, case study, integrated curriculum, integrated assessment*

The Call to Redesign the Curriculum

Education in the 21st Century has been and will be profoundly influenced by technology and globalization. Capabilities such as collaboration, communication, and critical thinking that have always been important elements in our education, have now taken on new meaning and relevance with technology advancements (Voogt, Erstad, Dede, & Mishatr, 2013). With the acceleration of digitalisation and adoption of technology at the workplace, 16 critical core skills as shown in Figure 1 have been identified under the SkillsFuture movement which was launched in 2015.

Figure 1. Critical Core Skills identified under the SkillsFuture movement

Ten micro-modules known as the Common Core Modules (CCMs) as shown in Figure 2 have been identified to be included into the DASE curriculum. These micro-modules are offered in either 15 hours or 30 hours per term/semester. It is equivalent to 1 to 2 hours per week for a 15 weeks long semester. The aim is to equip all Year 1 DASE students with the critical human and emerging digital skills through these ten CCMs so that they are competent and versatile to serve the communities and industries with mastery in a disruptive world.

Figure 2. Ten Common Core Modules identified to be included in DASE curriculum

Integrated Curriculum as an Effective Way to teach the identified Core Skills

Integrated curriculum has shown to be effective in academic learning with evidences in many studies. (Barr, Boulay, Selman, McCormick, Lowenstein, Gamese, Fine, & Leonard, 2015; Bordogna J., Fromm, E & Ernst, E.W., 1993, Drake, S. M. & Reid, J. 2010; Yoon, Dyehouse, Lucietto, Diefes-Dux, & Capobianco, 2014).

Since 2003, SP has been making efforts to move away from what we have known as modular curriculum system to a more integrated curriculum. Much efforts have been put in to integrate knowledge across technical core domain modules in SP which aims to enable our student to see the relevance in the modules they are studying, promote students' motivation, better student learning experience and consequently a more desirable outcome on the academic performance (Chong S.P., Chua K.C., Christopher T. & Patrick C., 2010; Koh, H.W. & Cheah, S.M, 2013; Pee S.H & Leong H., 2006).

However, the current integration efforts have been emphasising mainly on integrating technical modules while neglecting the socio-economical context where technical solutions are only part of the broader holistic solution. The introduction of these ten CCMs opens up the opportunities for the respective schools to explore how these modules can be paired with the relevant core domain modules so as to better teach the students the identified critical core skills more effectively.

In the following section, we will look at the overview of how the DASE under the SEEE is being revamped to include all the ten CCMs. We will then zoom into the actual integration work of pairing two relevant CCMs with one of the core domain modules under the pilot run for DASE.

Overview of the New Proposed DASE Curriculum

In this new initiative, DASE was identified as the pilot course to revamp its curriculum to implement all the ten CCMs. The purpose of the pilot run is to understand the operational issues that have worked well and also identified areas for improvement with concrete action plans so that it can be scaled up for other diploma courses to come on-board in the future. As the desired outcomes hinges very much on the integration of the CCMs and the relevant core domain modules, this paper will only focus on the work done in this area for the pilot run under DASE.

In order to integrate the relevant CCMs into DASE curriculum without increasing the total curriculum hours, a comprehensive study on course curriculum and analysis of the knowledge and skills was carried out. This is to find out if the critical core skills such communication and collaboration skills were already sufficiently covered in the DASE curriculum especially in the core domain modules. For example, project-based module(s) would usually have activities in place to provide students the opportunity to collaborate and work in teams in order to complete the project in the module. Such core project-based modules are suitable to be integrated with relevant CCMs such as CDA that specifically builds the students' communication and collaboration skills before the students start to work in their teams. After all the analysis and discussion with the relevant stakeholders, the new DASE Curriculum Structure with the integration of the CCMs was proposed and it is shown in Figure 3.

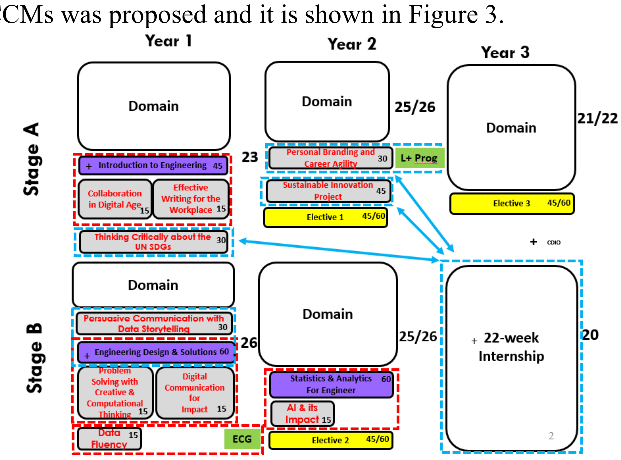

*Figure 3. The New Proposed DASE Integrated Curriculum Structure for AY21/22; *Domain here refers to the core technical foundation modules*

As shown in Figure 3, CCMs such as Thinking Critically about the UN SDGs (TCU) and Sustainable Innovation Project (SIP) which are in solo dotted blue boxes, refer to integrated transferable skills where students can apply what they have learnt in their relevant modules throughout the 3 years course of study. For example, the module TCU is designed to teach students skills such as how to ask good questions, identify different perspectives to issues and evaluate credibility of different sources. The students can then apply what they have learnt in core domain modules such as Engineering Design & Solutions and 22 weeks internship as indicated by the arrow signs. Relevant CCMs that are paired with the core domain modules are clustered and enclosed in red dotted boxes. For example, under Year 1 Stage A, the core domain module IE is paired with two relevant CCMs namely, CDA and EWW. To create an integral learning experience, CDA and EWW use the projects in IE as the

scenario or technical context in the teaching of the modules.

The Pilot Run

With reference to Figure 3, all the 1st year DASE students in their first semester will study the same common modules as listed in Table 1. Out of all the common domain modules, only IE module is a project-based module. As this module requires the students to work in teams, submit a report and complete a presentation for one of their project assignments, it becomes a natural option to pair it with two relevant CCMs, CDA and EWW, for the integration.

In order not to increase the total curriculum hours after the revamp, the existing hours to run IE is reduced from 60 hours to 45 hours. As it is designed as an integral learning experience for the students through applied practice of the paired CCMs with IE, there is no compromise in the specific learning outcomes even with the reduction of 15 hours in IE. The before and after changes in the Year 1 Semester 1 modules are shown in Table 1. Note the total curriculum hours remained unchanged after the revamp.

Table 1. Changes in the modules for Year 1 student in Semester 1 Before and After implementation

Before Implementation		After Implementation	
Module Code and Name	Hours	Module Code and Name	Hours
ET0083: Structured Programming	60	No change	60
ET0085: Computer-Aided Design & Drafting CADD	30		30
ET1003: Digital Electronics I	60		60
ET1005: Principles of Electrical & Electronics Engineering I	60		60
MS4121: Engineering Mathematics I	60		60
ET1013: Introduction to Engineering (IE1)	**60**	***ET1023: Introduction to Engineering***	***45***
		CC1407: Collaboration in the Digital Age (CDA)	***15***
		C1408: Effective Writing for the Workplace (EWW)	***15***
LC060: Critical and Analytical Thinking	**30**	***CC1401: Thinking Critically about the UN SDGs (UNSDGs)***	***15***
Total curriculum hours	360	Total curriculum hours(unchanged)	360

It is important to focus on the desired outcomes of integral learning experience of the paired CCMs and IE for the Year 1 DASE students. To achieve that, one of the existing projects in IE "Engineering Discovery (ED) Project" is used as the project scenario for both CDA and EWW to work on teamwork and to provide the technical context for report writing respectively.

The ED Project comprises of 15% weightage in IE. This project requires the students to form into groups of 4 or 5 students. Each group is assigned a different electrical home appliance to dismantle in the laboratory. The groups observe and study the actual electrical appliance and source for information to figure out the techncial design and how it works. Each group needs to do a presentation and submit a report for the assignment. The reasons for selecting the ED Project as the scenario for the paired CCMs are straightforward. It is the first teamwork project where all the first year DASE students work as a team. This is thus a natural synergy to pair this project assignment with CDA so that students will learn how to work effectively as a team where they use simple project planning and collaboration tools to manage team projects and apply their knowledge in their first teamwork project and also other subsequent modules that require teamwork. The existing ED project also requires students to write a report and do their presentation. However, the current practice does not require IE teaching staff to teach the students how to write a good report. Thus, by using the same ED project to pair with EWW, students can apply the principles of writing a good report learnt in EWW with ED Project as the scenario.

Table 2 shows the new teaching schedule for the IE project module and the paired CCMs. As shown, all the first year DASE students take CDA in the 1st term followed by EWW in the 2nd term while they take IE across the whole semester. This ensures the timely introduction of the knowledge and skills in CDA and EWW that are required in IE.

Table 2. Teaching schedule of IE and the paired CC modules.

<table>
<tr><th>Teaching Week</th><th></th><th>Introduction to Engineering (IE)</th><th>Paired CCC modules</th><th>The Integration via IE Engineering Discovery Project</th></tr>
<tr><td>1</td><td rowspan="7">Term 1</td><td rowspan="6">3 hours/week</td><td rowspan="6">CC1407: Collaboration in the Digital Age (CDA)

2 hours/week</td><td rowspan="6">IE provides the team project scenario for CDA on team work.

As the result of effective teamwork learnt in CDA, each group complete project study and do presentation in IE.</td></tr>
<tr><td>2</td></tr>
<tr><td>3</td></tr>
<tr><td>4</td></tr>
<tr><td>5</td></tr>
<tr><td>6</td></tr>
<tr><td>7</td><td colspan="3">Mid-semester Test Week</td></tr>
<tr><td colspan="5">Term break</td></tr>
<tr><td>8</td><td rowspan="8">Term 2</td><td rowspan="8">3 hours/week</td><td rowspan="8">C1408: Effective Writing for the Workplace (EWW)

2 hours/week.</td><td rowspan="8">IE provides the project scenario for EWW for report writing.

EWW uses IE ED project for report writing. The report will be used as a paired assessment by both IE and EWW modules.</td></tr>
<tr><td>9</td></tr>
<tr><td>10</td></tr>
<tr><td>11</td></tr>
<tr><td>12</td></tr>
<tr><td>13</td></tr>
<tr><td>14</td></tr>
<tr><td>15</td></tr>
<tr><td colspan="5">End of the semester Exams</td></tr>
</table>

Integration of IE with CDA and EWW

Figure 4 shows that students form teams in CDA in week 1. The same team will continue to work together for IE ED project. These students will then take IE ED Project as the scenario for their assessment work (70%) in CDA. At the same time, the students can apply what they have learnt in CDA to help them prepare for their presentation in week 6 for IE. Both lecturers from CDA and IE use the same online Learning Activity Management System (LAMS) to acquire self and peer feedback given by every member in the teams to assess on their teamwork performance.

In the 2nd term, the students learn the principles of good report writing in EWW. They use IE ED project as the scenarios to complete their individual report writing and submit the same report to both EWW and IE lecturers. EWW lecturers assess the report writing skills (70% assessment weightage for CDA) while IE lecturers assess the technical content (5% assessment weightage for IE). With the paired assessment, it is obvious to see one of the key advantages of pairing a core domain module with relevant CCMs is the reduction of workload for students. The benefit of integrated curriculum is that assessments can be implemented across paired modules in the same semester for a common assignment.

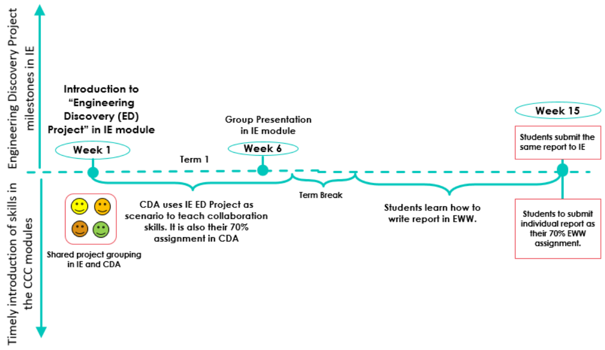

Figure 4. The milestones of ED Project assignment in IE and how the CC modules are aligned for the students to apply the skills in the IE ED project.

Results and Discussion A survey was conducted after the end of each term for all the first years students who went through the revamped curriculum in AY2021/2022 Semester 1 as illustrated in Figure 5.

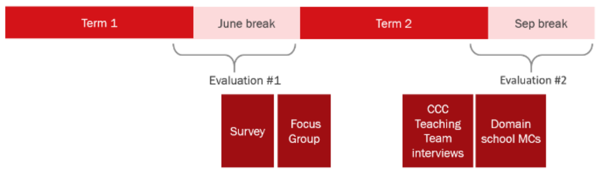

Figure 5. Timeline of the survey and focus group discussion at the end of each term.

A total of 75 (86%) and 80(92%) out of 87 DASE first year students responded to the survey conducted at the end of term 1 and term 2 respectively. The survey consists of a total of 8 items. 4 out of the 6 items are related to the pairing of CCMs with IE. The other 2 items are questions relating to TCU which will not be discussed here. The participants were asked to rank how much they agreed on the statements listed in Table 4 on a 4 point Likert-type scale (1=Strongly Disagree to 4 = Strongly Agree). A summary of the survey results relating to our study is grouped according to the subscale Knowledge, Comprehensibility and workload collected at the end of each term as shown in Table 4. There are also 2 open-ended questions asked during the focus group discussion: "How did you apply the things learned in the CC modules in your other DASE module? and "What is the most valuable idea or skills that you learned from your CC module this term? These questions aim to gather the students' perceived values of the integrated learning process after the revamp. The results of the 2 open-ended questions are grouped into positive, somewhat positive, neutral and negative sentiment as shown in Table 5 and 6 after applying sentiment analysis using Textblob, VARDER & STANZA techniques.

Table 4. Mean for each item for survey conducted at the end of each term.

No.	Item content	Subscale	Term 1 (n=75)	Term 2 (n=80)
1.	I learned useful skills in the module Collaboration in the Digital Age.	Knowledge	3.29 (0.46)	-
	I learned useful skills in the module Effective Writing for the Workplace.	Knowledge	-	3.54 (0.53)
2.	I understood what I was expected to do.	Comprehensibility	3.25 (0.47)	3.49 (0.50)
3.	By communicating and collaborating with others, I was able to learn more.	Comprehensibility	3.47 (0.50)	3.50 (0.50)
4.	The workload was manageable for me.	Workload	3.27 (0.47)	3.41 (0.52)
		Overall average	**3.32**	**3.53**

Table 5. Student Responses to "How did you apply the things learned in the CC modules in your other DASE module" with selected comments from students' responses in each of the sentiment category.

Sentiment	No. of student responses	Selected representative comment from students' responses in each sentiment response category.
Positive	31	*"Able to communicate better during group work and in future during project work, it'll be easier to write project"*
Somewhat positive	11	*"For IE module, a lot of team project work are required to be submitted. Using CDA module allows me to communicate with my teammates well."*
Neutral	5	*"I used the CRAAP when doing personal research on different topics from the modules. I also learnt about the UNSDGs and how it closely links with the modules such as healthcare, .etc and how to improve it."*
Negative	1	*"I cited sources that was used for assignment and did not used other people's hard work as my own."*

Table 6. Student Responses to "What is the most valuable idea or skill that you have learned from your CC modules this term" with selected comments from students' responses in each of the sentiment category.

Sentiment	No. of student responses	Selected representative comment from students' responses in each sentiment response category.
Positive	35	*"My most valuable skills is that I gained the ability to work with others and it is valuable because I believe that it will enable me to do a good job no matter where I go"*
Somewhat positive	15	*"Learning more about the UNSDGs was valuable for me, as previously I was not so aware of the goals that are supposed to be achieved by the countries all over the make the world better."*
Neutral	22	*"Collaboration skills and how to find reliable source."*
Negative	2	*"To be wary about the trail I leave on the internet since it can have long lasting effects on my reputation."*

Areas of Improvement

From the findings, the pairing of CDA and EWW with IE is a very positive one. More than 86% of the students responded agree or strongly agree to all the survey items. The survey results have been better than initial expectations. None of the students has responded with strongly disagree to any one of the items and only a very small percentage of the student population (no more than 5) disagree with a few items. Together with the written responses from the 2 open-ended questions, it is concluded that majority of the students:

- have had an overall positive sentiment;
- are very clear about the skills learnt in their respective module;
- are able to apply the skills they learned in CDA and EWW in the IE DE project;
- are able to relate to the purpose of the integrated curriculum as they see the applications of the skills learnt in the domain modules; and
- value the importance of life skills learnt in CCMs.

After the survey, a focus group discussion with 9 DASE students was conducted shortly. The intent of the focus group discussion was to find out more about the student learning experience in the CCMs. All the 9 DASE students attended the focus group discussions were nominated by their respective CC lecturers. Each focus group discussion was facilitated by a CC lecturer who did not teach the students. DASE Course Chair, module coordinators of paired CC and IE modules and a representative from Education Department were invited to attend the focus group discussion.

From the discussion, all the students shared that the skills learnt were useful and they were able to cite specific examples of how they applied the skills learnt in IE and beyond.

"Using credible sources to find information on appliances and putting a report together on how certain appliances can be more sustainable using analytical methods learnt in EWW. We can use these skills in our other modules and when we go out to work." commented by one of the DASE students in the focus group.

However, from the focus group discussion, some students pointed out that there seemed to be some miscommunication in the instructions given by their CC and IE lecturers. This could be due to the fact that the size of the teaching staff team was huge (~20) and it was not easy to ensure all the teaching staff understood what was needed to be communicated for the pilot run with just a mass briefing session. Thus, a communication plan will be introduced to have an effective communication of CCC to all students and staff. In the communication plan, it includes identifying the key stakeholders, the methods and platforms to communicate with them and also to come out resources for the communication kit.

Issues and Challenges

There were challenges in the integration process especially in the pairing the domain and the CCC modules. Though there is no increase of curriculum hours and manpower after the implementation, there were many meetings arranged to resolve issues raised by students and teaching staff during the semester. For instance, minor tweaking of teaching schedules and redesigning of the assignment for better alignment between the domain and the CCC modules were just some of the challenges.

Another issue is to consider the management of students who fail either domain or CCC module. If a student fails the either of domain or CCC module, the student will need to repeat that particular failed module. After much deliberations with the module coordinators of the domian and CCC modules, the conclusion is that it is unlikely to cost much of an issue except that the student will not be able to to be actively involved in the integrated assignment. The plan is for the module coordinator of the domain or CCC modules to customise the assessment plan for the failed students. It will be fair and applied consistently for all the failed students. Special care will also be taken in assigning the failed students to the teaching staff who are more familiar in managing the failed students.

Conclusions

The paper presented the initial works and the actual integration efforts by pairing the domain module, IE with two relevant CCMs, namely CDA and EWW in the pilot run for DASE. One of the benefits of pairing the domain module with relevant CCMs is the lessening of workload for students since they only need to submit one common assignment for both their domain and CC modules. Another advantage is that students can apply the CC skills learnt in their paired domain modules and beyond.

From the survey results, the students find that the pairing of CDA and EWW with IE is a very positive one. Majority of the students are able to understand what to do, see the value of the integrated curriculum and able to apply the skills learnt in CC in the IE module with manageable workload. The overall survey results and focus group discussion showed the students have benefited from the integrated curriculum structure.

It was a long journey to put the pieces together and figure how to deliver the teaching. It has been fortunate that the all working members involved in the integration work were able to see the value of the initiatives and even find it rewarding to see the students come up better quality reports and presentations compared to the past batches. However, no survey was conducted for all the teaching staff involved in the pilot run. Thus, the teaching staff's readiness, beliefs and perceptions related to integrated curriculum was unknown.

Looking ahead, there are many more challenges as we are scaling up the initiative to other diploma courses**.** With the experience learnt from the pilot run, especially the very positive feedbacks from the staff and students, it gives us the confidence to forge ahead to implement the CCC in all the EEE diplomas at SEEE.

Acknowledgements

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SMART TEACHING IN BEAUTY THERAPY

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Abstract

Tradition teaching in beauty therapy and make-up techniques involves face-to-face skin analysis and consultation between tutors and students. Students may need to try lots of cosmetic products before knowing the right kinds of cosmetic products to be used. Also, they may need to do lots of skin test to determine their types of skin. This may increase stimulation on skin and results in skin irritation and sensation. Students with sensitive skin may not be suitable for frequent skin test and cosmetic product applications.

SMART make-up and skin care technology is also popular in the industry nowadays. Augmented reality (AR) mirror is introduced in the beauty and personal care products industry for preliminary make-up and skin analysis. Students can have a quick review on the result of make-up and skin characteristics before face-to-face consultation by using the virtual make-up function in the AR mirror. Advice from the mirror will be given to students based on analysis of skin and then help the students to select the right and suitable kinds of make-up and skin care products. Students can see the results of different colour decoration on face for different occasions so that the right kind of cosmetic product can be chosen. Then, students can work out the suitable make-up for right decoration on face for different occasions. In this way, students can use and select cosmetic products in a health and safe way by using SMART technology. Preliminary cognition on skin characteristics and the results on the usage of different cosmetic products is important as students do not need to apply cosmetic products directly on skin to prevent allergy arise. This can also let the students with sensitive skin to learn safely.

Face-to-face teaching such as make-up techniques, skin care routine and selection of products will be delivered to students so that they can comparison on SMART technology application in beauty industry nowadays.

Keywords: *SMART make-up, augmented reality (AR) mirror, skin analysis, skin care, cosmetic products*

Introduction

Traditionally, teaching of beauty therapy and make-up techniques required to delivery plenty of workshops for students to practice on related hands-on experiences in order to have proficient techniques to work as beautician and stylist after graduation.

There is a growth in the consumption of cosmetic products in teenage. Selection of the right products for different skin types are most concerned. To keep a health and beauty appearance smartly, knowledge in selection and application of suitable cosmetic products by using most up-to-dated technology are needed.

SMART make-up and skin care technology is also popular in the industry nowadays (Loreal, 2019 and Saini, 2020). In this way, students can use and select cosmetic products in a health and safe way by using SMART technology. Students can have a quick review by using the virtual makeup function in the AR mirror. Students can see the results of different colour decoration on face for different occasions so that the right kind of cosmetic product can be chosen. Then, students can work out the suitable makeup for right decoration on face for different occasions. (Figure 1)

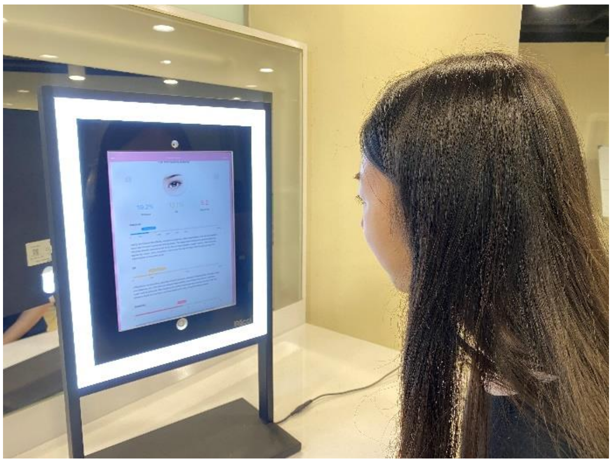

Figure 1. Application of SMART mirror in vocational training.

Hands on and face-to-face make-up techniques will then teach the students so that they can have comparison on the virtual and real makeup results.

Throughout the use of SMART beauty teaching, students will experience the use of big data (Anthony Lucas, 2022) for skin analysis, product selection and make-up techniques.

Pedagogy

Traditional teaching on beauty therapy and make-up techniques will be compared to the SMART teaching in beauty therapy and related modules.

For traditional teaching on beauty therapy and make-up techniques, the learning and teaching for beauty therapy and related modules aims as to teach the students to select and perform suitable facial, eye and wax treatments for clients based on skin analysis and consultation. For make-up techniques and related modules, the learning and teaching aims as to teach the students to select suitable make-up for clients and perform make-up on eye and for different occasions based on face shape and skin type analysis. Just like most of the modules, students also need to learn theoretical knowledge for beauty therapy and make-up techniques before starting the workshops. For beauty therapy and make-up techniques modules, techniques of different facial treatments and techniques of make-up for eye and different occasions will be taught in workshops.

For SMART teaching in beauty therapy and related modules, the learning and teaching aims as to teach the students to select suitable make-up and skin care products based on the analysis by AR technology and perform make-up for different occasions and skin care routine. Just like most of the modules, students also need to learn theoretical knowledge for beauty therapy and make-up techniques such as applications of SMART make-up techniques and SAMRT skin analysis and skin care before starting the workshops. Techniques of different beauty treatment and make-up techniques will be taught in workshops. The workshops include face-to-face teaching of essential products and tools for make-up techniques, treatment area preparation, procedures for make-up application and removal for different occasion's make-up and routine skin care and product selection. Techniques of different SMART beauty will be taught in workshops. The workshops include make-up trial by using AR technology, skin analysis trial by using AR and skin measurements (such as skin moisture content, skin sebum, skin pigmentation, skin elasticity, etc.).

Results and Discussion

Workshops in traditional beauty teaching for students require practicing with a model in each lesson. The model that the student selected may always be the same person throughout the workshops in one module. As the same model is chosen, students cannot familiar with different types of skins and characteritics from different persons although their hands-on skincare procedures for treatment is well learnt. In addition, students cannot familiar with different types of skins for different nations although they can change their Asian model for practice frequently.

Cosmetic product selection for different types of skins is another important part that is taught in workshops in traditional beauty teaching. Based on skin analysis taught by tutors, students will learn how to select suitable cosmetic product based on the experiences from one or two tutors in the lessons. This may result in bias and subjective facial and product analysis. This may narrow the knowledge on product selection in traditional beauty teaching.

On the other hand, students may get inflected easily especially under pandemics due to the plenty of workshop practices. The safety and hygiene control is important in the workshop practices. For students with sensitive skin and when the "Wearing of Mask" ordinance is active, students may not have the chance to practise well. Under all these situations, traditional beauty workshops training becomes difficult to operate and maintain for students.

For the SMART beauty teaching, student can learn on skin analysis and product selection in an objective way by the use of big data in the SMART mirror. Students can experience automatic adjustment of lighting for facial recognition and skin analysis by the use for SMART mirror in lesson. (Figure 2)

Figure 2. Facial recognition and skin analysis by using SMART mirror.

Students can track the appearance of skin and determine whether the cosmetic product that used actually made a difference in the appearance by the use of SMART mirror. Students can learn for skin analysis and personalised product selection recommendation from the mirror. This can also help the students to personalise the most suitable beauty routine for skincare objectively.

For the SMART make-up techniques, students can experience a combination of make-up results virtually by the use of AR technology in the SMART mirror. Students can test out a trendy new hair colour or lipstick shade

through the SMART mirror and allows them to see what look like at the present combined with a digital overlay of your desired beauty look. (Figure 3)

Figure 3. Make-up techniques by using SMART mirror.

This can help students to make sure to buy the right beauty products. As SMART beauty and make-up teaching involves training in front of SMART mirror instead of practising with models in lessons, chance of cross inflection can be reduced.

Conclusions

In conclusion, students can learn beauty treatment and make-up techniques in an objective way during SMART beauty training when compared to tradition beauty training. Students can also experience the use of new technology and big data in SMART beauty training. In addition, SMART beauty training is also suitable under pandemics as face-to-face contact between students and their models and tutors can be reduced when compared to traditional beauty training.

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HOW INPUT AND OUTPUT ACTIVITIES TO FOSTER A GLOBAL MINDSET WERE IMPLEMENTED INTO THE INSTITUTIONAL PROJECT

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Abstract

This study describes how input and output activities to enhance English communication skills were implemented into our institutional project. This project was established as a way to foster a global mindset among students. Since 2004, the Department of Electrical and Electronic Engineering has installed Extensive Reading (ER) programs in its English classes to improve language proficiency. Our research reveals that students who have completed a seven-year-long ER program, in which they read over 1 million words, have TOEIC scores equivalent to those who have studied abroad in an English-speaking country for ten months. However, since most students will graduate before seeing such a result, additional exposure to English through other means is necessary. Therefore, we have established a science class taught by a native English speaker to increase input. In addition, we have set up several extracurricular activities to increase output. The data shows that the standard of the distribution of TOEIC scores has been raised, meaning the ratio of students who had scored more than 400 points increased in 2021 compared to previous years (2006-2010). The results show that increasing input has made a significant difference in improving English communication skills. However, more opportunities for output should be given to develop these skills further. We have woven several output activities into our global project. One activity is International Exchange Video Contest, which offers students an opportunity to partner with students from different cultural backgrounds to make a video together. In the last three contests, about 100 participants took part from several countries. After analyzing the video submissions, we found that most participants excelled at teamwork but faced difficulty developing their ideas. We have also organized TEDxToyotaKOSEN. This event was an excellent opportunity for global education. In this way, we would like to explore how input and output activities have been brought together to optimize students' English communication skills.

Keywords: *global education, extensive reading, output activities, TEDxToyotaKOSEN, SDGs*

Introduction

Since the start of the COVID-19 pandemic, educators have struggled to promote international projects as part of their educational activities. However, despite the many obstacles, the National Institute of Technology, Toyota College (hereon referred to as Toyota KOSEN) has continued to pursue projects that develop international and intercultural relationships. The Global Engineering Project (GEP), which was started in 2020, aims to foster a global mindset among Toyota KOSEN students by enhancing their English communication skills. This was achieved by integrating both input and output activities throughout the academic year. Extensive Reading (ER) classes and an English-based science class taught by a native English speaker were conducted for input activities. Toyota KOSEN sought alternative methods for output activities due to the COVID-19 pandemic. The paper describes the input activities' results and how we were able to install alternative output activities. The paper aims to explore how both input and output activities were utilized to foster a global mindset among students while simultaneously developing their understanding of Sustainable Development Goals (SDGs), a mindset that is integral for students' futures as both global citizens and engineers.

Background

It has long been discussed that Japanese learners of English suffer from low communication skills, despite a growing need for English speakers in society. One of the main causes of this low communication skill is a lack of exposure to the target language in an EFL (English as a foreign language) environment. Language educators should provide students with enough opportunities for input and output. However, this still poses a challenge due to limited class hours for learning English.

One method to increase input and develop their fluency is ER. Day and Bamford (2002) determined the nature of ER programs with ten principles. In Japan,

Sakai (2002) proposed ER with three golden rules. Furukawa (2020) created a guidebook indicating how learners should start ER. He also organized the Start with Simple Stories (SSS) group, which collects information on books, such as their YL (*Yomiyasusa* Level; readability level), word count, and review. This information is a helpful resource for both learners and educators. It should be noted that ER does not adopt the translation method. Therefore, ER learners are strongly encouraged to begin the program by reading easy-level books while unlearning their previous habit of translating English text into Japanese. Since 2004, the Department of Electrical and Electronic Engineering in Toyota KOSEN has installed ER programs in its English classes to improve language proficiency. The research reveals that students who have completed a seven-year-long ER program, in which they read over one million words, have TOEIC scores equivalent to those who have studied abroad in an English-speaking country for ten months (Nishizawa, Kamiya, Ichikawa, Salmasan and Ohno, 2022).

On the other hand, Toyota KOSEN programs primarily focused on input activities. One primary reason is that ER is a practice that embodies the input hypothesis in Second Language Acquisition (SLA). However, as Swain (1985) has proposed, output is also necessary for language learners to develop communication skills. Nowadays, it is widely recognized that both input and output are necessary for language learning. Further discussion is necessary to establish the optimal balance between input and output exercises and how much and what type of activity is appropriate in an educational setting.

Since Toyota KOSEN decided to adopt GEP, the Center for International Exchange has reorganized its educational activities so that students can improve their English communication skills and foster a global mindset as future engineers. For the latter part, we have implemented the concept of SDGs as an indispensable objective. SDGs are a set of 17 goals adopted by the United Nations in 2015 which aims to end poverty, protect the planet, and ensure peace and prosperity for all people by 2030. SDGs require an integrated approach in both the public and private sectors. Educators must consider not only how to teach the concept but also how to realize it in their educational platform. Toyota KOSEN is an institute that fosters future engineers who will contribute to their industries while dedicating themselves to improving the well-being of people everywhere. Students must acquire knowledge of state-of-the-art technology and learn how this technology affects society. Therefore, students should be given ample opportunities, or so-called "learning through practice," in which they can interact with people who have different cultural backgrounds and work together to find a solution that would improve our world. This is an essential part of the SDGs' aim and vision; thus, we have made it a pedagogical requirement for our projects. Projects such as the International Exchange Video Contest (IEVC) and TEDxToyotaKOSEN (TEDxTK) are built on this belief.

The paper is organized as follows: first, we will discuss a new type of English class for furthering input. Second, we will look at how we implemented two different projects that focused on increasing output.

Method 1 Input Activities

As mentioned above, ER is a promising method for enhancing students' fluency as measured by their reading comprehension TOEIC scores. It was expected that further input would lead to students improving their communication skills.

The second input activity is a year-long science class for third-year Toyota KOSEN students taught by a native English speaker. This class gives students the opportunity to study science in English without having any experience studying abroad. Students take the 90-minute class once a week, a total of 15 times each semester which increases the exposure to English speaking compared to the past. The class teaches fundamental physics and chemistry at a level equivalent to first-year high school. The students have learned these subjects in Japanese before attending this class; thus, they have no first learning input in science contents. This course was established in the first semester of 2020 when classes were conducted online due to COVID-19. After 2020, students could return to school to attend classes in person. The number of third-year students was 269 in 2020 and 226 in 2021.

At the end of each semester, students must answer an academic survey containing eleven indexes for each of their classes. The indexes are: understanding of the lecture's goals and purposes, self-studying level, explanation level, understanding level, interest level, teaching behavior of the teacher, lecture preparation and speed by the teacher, effectiveness of homework, lecture quality, learning environment, and response of the teacher to the students' survey result. Students must give grades between one and four for each index, where one means poor/low, and four means very good/high.

Method 2 Output Activities

We have woven several output activities into our global project, organizing the educational system so students can obtain school credit by engaging in the activities. Productive skills attained from output activities are difficult to measure quantitatively compared to input activities. In particular, measuring how a student's attributes are developed is difficult. We regard the activities for output as an opportunity where students can apply their communication skills in a practical setting. Also, we projected that students were able to learn SDGs through practice. During output activities, students are the subject of learning and must engage in the activity autonomously. Here, a teacher's job is not to teach materials related to SDGs in English but to create and organize a learning environment and help students work on the projects as a facilitator. It was

quite a challenge for students to pursue a question with no correct answer and for teachers to give the right amount of support so that the students could progress in the projects. If the teacher does not give proper guidance, the students may lose their way and become demotivated. This paper describes the first step we took to implement these SDG-related projects, focusing on two activities, IEVC and TEDxTK. In both projects, we expected students to develop their language learning while cultivating their characters.

IEVC (International Exchange Video Contest)

One project we implemented into GEP is IEVC. Toyota KOSEN held the contest three times; the first and the second in 2020, the third in 2021. The contest was launched to give students an opportunity to interact with overseas students even during the COVID-19 pandemic. The contest theme was "What can we do for a sustainable society?" The participants made a 3-minute video in pairs consisting of one Toyota KOSEN student and one overseas student. The objectives are to improve their English communication skills, learn from people with different cultural perspectives and enhance their information literacy. Microsoft Teams has been used to manage the contest, providing them with the detail, responding to the questions and submitting the videos. In the contest, the winner was initially invited to join a short-term seminar held in Toyota KOSEN in Japan. However, the winners have so far been unable to enter Japan due to the restrictions on new entries by foreign nationals.

The contest takes about five months, including the application and judgment periods. Students spend about two months making the videos. The following section describes the flow of the contest in seven steps. First, we call for participants from Toyota KOSEN and overseas schools affiliated with Toyota KOSEN in some way. So far, we have had participants from several countries. Students applied through Microsoft Forms. Second, we pair the Toyota KOSEN students with overseas students. Third, students begin communicating with their partners. During this time, participants spend about one month working on three practice videos before their final submission. In the first video, students must introduce themselves in a one-minute presentation. In the second and third videos, students discuss their SDG topic in a two-minute presentation. The participants must submit their presentations as a restricted video on YouTube. It should be noted that staff members give feedback for every video submitted on time so that students can improve their English presentation skills, content and video editing skills. Fourth, they spend three weeks working on their final three-minute video presentation. Fifth, a panel of 10 to 15 judges consisting of staff from Toyota KOSEN and other organizations evaluates the final videos. The videos are evaluated using a set of criteria revealed to the participants beforehand. The criteria are: English speaking ability, presentation of facts, presentation of opinions, teamwork and visual aids, with opinion and teamwork weighted more heavily. The judges evaluate each criterion on a scale of one to ten points, submitting their assessment on Microsoft Forms. Sixth, the evaluation forms are collected and the points are then tallied. After the scores and the submission points have been tallied, the contest winners are announced. Lastly, we conduct an online award ceremony and send certificates of participation to any overseas students who opt to receive one.

The teachers in charge of the contest responded to frequent inquiries from participants, maintained contact with teachers and staff members from other schools, ensured the students were getting along with their partners, checked all of the video submissions and explained the grading criteria to the judges. The staff for the contest did not evaluate the final videos but offered feedback for the practice videos.

We modified the procedure of the contest each time. We included participants from senior high schools in Toyota City during the second contest. From the second video contest, we began organizing meetings and online seminars so that students could get to know each other and further their understanding of SDGs before they began working on their videos. We outsourced parts of the program to business companies whenever they offered a service that we thought would benefit the students' learning experience. In addition to these changes, we hired former video contest participants as teacher's assistants (TA). These TAs were tasked with conducting a weekly meeting with participants to help them with the video and presentation creation processes and any other concerns they may have about the contest.

TEDxTK (TEDxToyotaKOSEN)

TEDxTK was organized in line with GEP, aiming to develop students' global mindset. In the summer of 2021, Toyota KOSEN acquired the TEDx license. Our school decided to run the TEDx event on 26 February 2022. We decided to host this event in place of a short-term in-person seminar we had initially organized because the seminar was deemed too difficult to hold due to the COVID-19 pandemic. The winner of the video contest was to be invited to the seminar, so we chose TEDx in part so that the winners could still visit Toyota KOSEN. However, the plan to invite the contest winners is yet to be realized. Apart from that, we took TEDxTK as an excellent opportunity for students and teachers to run a project with global standards. We also adopted SDGs as the central theme for TEDxTK. The event involved three job roles: assisting the speakers, managing the student committee and negotiating with the school administration on matters such as the budget.

The first role is concerned with the TEDx speakers. We posted a call for in-school and out-of-school applicants on the school website. After interviewing the applicants, eight speakers were recruited for the TEDx presentation. We corresponded with the applicants for three months to brush up on their ideas and meet the TED goal: ideas worth spreading. This event differed from

previous English events, such as the speech contest held in English, because TED prioritizes the idea itself. Many of the student speakers found it difficult to come up with their unique ideas, instead espousing the ideas of others. Students tended to underestimate the value of their idea and gravitated toward ambitious ideas that lacked a strong message. The staff members took their time and energy to help them find and shape their idea, encouraging them to reflect on their own experiences. Once the students could make that part clear, the rest of the preparation process went very smoothly. We were so involved in the creation process of the scripts themselves due to our guiding nature as teachers and our pride in having the opportunity to represent Toyota KOSEN in such a highly regarded event.

The second role was to manage the student committee. We expected to find enough student staff members because TED appeals to students who want to learn English and are interested in creating things as engineers. As expected, more than 40 students from various departments and grades joined the committee, with nine volunteering to head the committee and its sections. The committee consisted of four sections, program director, design & decoration, workshop and IT, with each section being assigned two leaders. The program director section was in charge of the proceedings during the event. The design & decoration section was responsible for designing and creating the venue, including the event logo and promotional posters. The workshop section planned the post-presentation workshop session in which speakers and participants discussed the SDGs. The IT section was responsible for the website and handled on-site audio and visual devices. One student served as the committee president and worked to manage the situation among the four sections. What made the student committee so great was that the leaders autonomously worked on the project and pursued an outcome in a thoughtful way that met the expectations per the TED requirements. For example, the leaders translated the TED regulations into Japanese to ensure that the regulations were not infringed upon unintentionally. In addition, the committee leaders gathered many ideas for making the event more fun and interesting from other members. The committee even filmed interviews with the speakers and played the videos before the speakers' presentations to inform the audience of their background. The committee designed the stylish posters by themselves and decorated the site with beautiful pillars. The committee also organized the post-presentation workshop, and the students successfully created an environment in which attendees could engage in the discussion together. The IT section provided integral support through their expertise in computer and audio devices.

Although every member utilized their skills, the leaders faced many problems leading up to the event. Therefore, the teachers held meetings with the leaders almost every day for two months before the event. Some problems were due to a lack of communication between students, while others came from a lack of knowledge of TED regulations. Sometimes, the leaders were upset with the issues, so the teachers worked with them to find a solution.

The last role was to negotiate with the school administration. Before the event, we were forced to consider the unappealing possibility of holding the event online because of surging infection rates. The administration had difficulty deciding whether to allow the event to be held in person. Therefore, the teachers made several contingency plans and estimated how much risk would be involved with each plan and how we could manage the risk. We decided to ask everybody attending the event to monitor their health a week beforehand and take an antigen test before coming to the event. This included all of the staff members as well. Finally, the administration gave us the green light under the condition that we make some alterations to our initial plan. The change was regarding the interaction between participants, including staff members. The administration was concerned that the participants would become excited and boisterous, leading to potential infection. In order to ensure that this would not happen, we had to ask the committee leaders to amend their plan, particularly during the workshop segment, to control their excitement. Indeed, it was the biggest problem we faced. In addition, we set up a new section in charge of enforcing COVID-19 protocols.

Results

The average scores of the academic survey for Kagaku Kiso Eigo in the first semester of 2020 were 2.7 and 2.6 in the second semester. The average scores for Kagaku Kiso Eigo in the first and second semesters of 2021 were 3.0. The score difference between the first and second semesters is negligible even though the lectures were conducted online in the first semester of 2020. The difference between 2020 and 2021 is 0.4 on average, and the "lecture preparation and speed" index significantly increased by 0.5. Figure 1 shows the ratio of the academic survey score of the "Understanding of lecture goals and purposes," "Understanding level," and "Interest level" index for 2020 and 2021. The average "Understanding of lecture goals and purposes" score was 2.8 in 2020 and 3.2 in 2021. The ratio of number one, very poor, and two, poor, decreased in 2021, which is the reason for the upward average score. This result indicates that students in our college not only began to accept learning science in English but even considered it a necessary part of their education. The average "Understanding level" and "Interest level" were 2.4 in 2020 and 2.7 in 2021. The ratio of the number of both indexes appears to be almost the same pattern. The number of students who checked "very good" is the same ratio, and the percentage of students who checked "very poor" decreased, increasing to "good" between 2020 and 2021. It is understood that motivation or interest in a subject improves understanding among learners.

As a first result of the academic survey, the lecturer modified the delivery contents, the education method,

and the questioning technique in 2021. The lecturer felt that the lecture level was too high due to the level of the scientific terms in English, so they reduced the number of topics. Furthermore, the lecturer used How- and Why-questions to encourage discussion. The following modification was implemented to give additional time for pair work and group activities. These educational improvements were better suited for students' understanding of the topic in English, and the average score of the academic survey increased significantly. Consequently, students were able to understand the purpose of studying science in English, and they were interested in the contents of the lecture; therefore, the understanding level of the class increased in 2020.

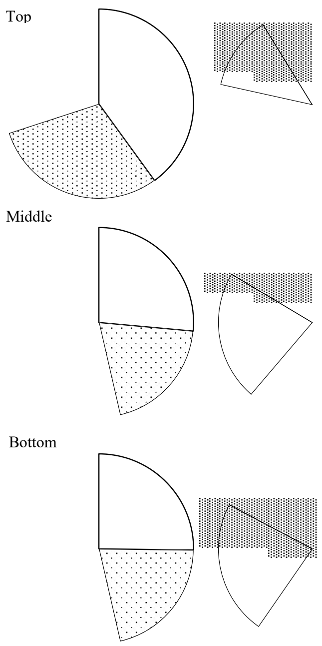

Figure 1. Pie graphs indicating the ratio of the four score academic survey results of the lecture. The left shows the results for 2020 and the right for 2021.
Top: Understanding of lecture goals and purposes, Middle: Understanding level, Bottom: Interest level
White: number four, very good/high, Slightly dotted: number three, good/high, Thick dotted: number two, poor/low, Black: number one, very poor/low.

In addition, another data shows that the standard of the distribution of TOEIC scores has been raised, meaning the ratio of students who had scored more than 400 points increased in 2021 compared to previous years (2006-2010). The average score was also improved from 372 to 402 in 2021, even when all of the students in the fourth grade were required to take the test (Nishizawa et al., 2022). The results show that increasing input has significantly improved English skills in reading and listening comprehension.

As for the outcome of IEVC, the biggest one is that we had 98 participants in the last three contests from Thailand, Vietnam, England, Finland, Brazil, Germany and Japan; 20 participants for the first contest, 52 for the second and 26 for the third. According to the evaluation, students were good at speaking English and describing the facts. Compared to those aspects, opinion and teamwork were relatively low (Table 1). It can be said that students found it hard to develop their ideas and express them through collaborative efforts. As mentioned above, those two aspects were highly evaluated, so the pairs who scored well in these aspects earned a higher overall score.

Table 1. The average scores

Evaluation criteria	Speaking	Fact	Opinion	Teamwork	Visual Aids
1st contest	7.10	6.95	6.97	6.87	6.82
2nd contest	6.42	6.78	6.43	5.75	5.95
3rd contest	6.99	6.96	6.67	6.59	7.15

TEDxTK proved that KOSEN has excellent potential to conduct such a global event successfully. Until then, the only educational institutions that had organized a TEDx event in the region were universities. Here, we will describe the outcome from three perspectives; teachers, student staff and the participants, including the speakers. What made a difference was that teachers proactively got involved in the event. Teachers regarded TEDx as an opportunity for presenters to spread their ideas and an educational practice where students can grow.

Student staff also appreciated the opportunity for teachers and students to tackle issues together because such opportunities were uncommon in the classroom. The student staff leveraged their skills and fulfilled their tasks in each job section. The leaders found teachers' support very helpful because contacting speakers and managing the event financially was too much for them. On the other hand, they sometimes felt frustrated with managing the tasks as scheduled, making adjustments to their plans with other leaders, having frequent appointments with teachers and getting approval from the administration. Engaging in the event was a tremendous challenge for everyone, so trial-and-error was inevitable. What made this undertaking all the more impressive was that the student leaders accepted the challenge and left a large amount of feedback that the next generation could use as reference. The project clearly illustrates how hard the students had worked and how much they had learned through organizing the event.

From the participants' perspective, this allowed adult speakers to share their SDG-themed ideas with the public. Also, it was clear that the student speakers developed their ideas, and the audience appreciated the presentations. We collected 38 people: 21 from outside school and 18 from Toyota KOSEN. At the end of the event, we circulated a questionnaire, which was answered by 29 out of the 38 participants. Everybody who answered the survey said that they appreciated the event. Some of them mentioned that they enjoyed the workshop where they discussed the SDGs with the speakers. They were also satisfied with the accommodations and the COVID-19 prevention

measures the staff provided. From the perspective of language education, many student participants expressed difficulty understanding the presentation in English. The questionnaire indicates that all the participants appreciated the leaflet we had handed out that contained abstracts written by the staff of the presenter's speeches in both English and Japanese. Also, some respondents said they wanted the TEDx presentation in Japanese or in a hybrid style that incorporated both English and Japanese. TEDx regulations do not mention any language requirements, but it was a point that the teachers and some of the leaders had discussed prior to and after the event. The student organizers insisted that they should receive detailed scripts of all the speeches beforehand so that they could give the subtitles in English or Japanese when presenting. They argued that, otherwise, Japanese participants would fail to understand the content. On the contrary, teachers saw this as a challenge as education practice, hoping that the experience would trigger their motivation to learn English. After discussions with the student leaders, we decided to provide participants with the leaflets.

Discussion

A bottom-up approach to students' English proficiency was promoted with more input. Giving students more opportunities for output was an effective way to push them to learn English. Additionally, we found that output programs provided an opportunity to optimize their communication skills. IEVC developed their communication skills in English and their technical skills in a collaborative situation. TEDxTK was an excellent opportunity for students to combine their expertise and skills. It reveals that Toyota KOSEN can be where knowledge creation takes place. For the student staff, organizing the event for half a year made them consider initiatives that would benefit themselves and others. Through the organization and execution of the event, students were able to practice the concept of SDGs, encounter new ideas and then solve the various issues and challenges in collaboration with others. It is often said when discussing SDGs that the practice should be related to an international matter. However, the students had successfully collaborated in their own context while still attaining a global standard. The project gave opportunities for students to practice the various skills and values that go into preparing for a presentation. It was an excellent moment for teachers to work on the event with their students and see them grow throughout the project. As such, output activities should not only be for learning a language but for learning other valuable skills as well.

This indicates the learning method, CLIL (Content and Language Integrated Learning), is effective, characterizing the practice with its nature: not "learn a language" but "learn by doing." CLIL has emerged in Europe within diverse contexts; the conceptual framework orientates the integration of language and content for deeper learning (Coyle, Hood & Marsh, 2010). It has been recognized in classes in Japan as a practical way to learn other languages and cultures. We advocate the approach and contend that through CLIL, students are given an opportunity to go beyond the classroom, especially when learning matters related to SDGs. This is because SDGs are not a concept that should not be limited to learning in class but is a concept that requires real-world action.

Conclusion

This paper described how Toyota KOSEN had implemented input and output activities into their educational system. We are currently at a crucial turning point where deeper and more practical learning should be conducted inside and outside the classroom. We found that our practice has the potential to become a role model for other KOSEN institutions. Of course, it is a tremendous challenge that requires many improvements. For example, there is still the question of how output activities should be optimized to benefit all the students, as well as how the school should incorporate the concept of SDGs into daily classes. It is also necessary to explore how we can measure the development of the students quantitatively.

SDGs are a concept that both schools and society must pursue. As such, we should find a way to build a bridge between learning and practice in a pedagogical way.

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UTILIZATION OF THAI-JAPANESE-ENGLISH TERMINOLOGY GLOSSARY FOR THAI STUDENTS IN THE LOWER GRADES OF KOSEN IN JAPAN

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Abstract

This is the introduction of our efforts to support international students from Thailand who do not understand Japanese. In 2018, three Thai students enrolled in the first grade of the National institute of Technology (KOSEN) Ibaraki College. This program is the first attempt to accept international students to the first grade of KOSEN. In this program they enter KOSEN together with Japanese students and spending time together, they can eliminate gaps in age and learning, and deepen bonds of friendship between students. However, the problem with this program is their Japanese language skills. Since Thai students of this program enter KOSEN just after graduation from junior high school, their Japanese language skills does not reach the level of understanding the lectures. Therefore, various support systems have been designed to help them understand the lectures, and it is found that Japanese language education specialized in science and mathematics subjects is necessary for them to understand the lectures. One of the most effective supports is to make a technical term glossary of Thai - Japanese - English for international students from Thailand. This glossary is a collection of basic and elementary technical terms to help Thai students understand the lectures of science and mathematics delivered in Japanese. This glossary can also reduce stress and pressure on Thai students if used as a learning material for preparation before studying in Japan. In this paper the author who has supported Thai students for the past four years looks at what has worked and what has not from the perspective of students and teachers.

Keywords: *support system, international students, Japanese, Thai, glossary, technical terms*

Introduction

As the number of international students in Japan increases year by year, according to the result of an annual survey of international students in Japan conducted by the Japan Student Services Organization (2021), 242,444 international students were enrolled in higher educational institutions and a Japanese language schools in 2021, although the number has decreased due to COVID-19. Among them 453 students were enrolled in the National institute of Technology (KOSEN). International students transferring to higher education institutions generally come to Japan after graduating from high school in their home country, however, 12 to 24 Thai students have enrolled KOSEN directly after graduating from junior high school every year. They are the first to fifth batch students of the Thai government scholarship program.

Since 2018, KOSEN Ibaraki College has entered into this new program for accepting lower-grade international students by arranging with Office of the Basic Education Commission (OBEC) in the Ministry of Education of Thailand, and has accepted several international students each year selected from the 12 Princess Chulabhorn Science High Schools in Thailand. Until then, international students who enrolled in our school usually have studied Japanese for one year at a Japanese language training centre in Tokyo after graduation from high school in their home country, and then transferred into the third grade of KOSEN. In comparison with that, this program is the first attempt to accept international students from Thailand to the first year of KOSEN. We have perceived this program as a considerable challenge. We expected the merit of this program is that (1) they can take education in technology at KOSEN earlier, (2) they can graduate from KOSEN and become engineers two years earlier than conventional programs, (3) by enrolling and spending time together with Japanese students of the same age, students are able to eliminate age and learning differences and strengthen bonds of their friendship, and (4) Japanese students can reap the benefits of global education at an early stage, including an understanding of foreign cultures and increased motivation to learn English and study abroad.

However, this program has also some disadvantages. First of all, they leave their home country at a very young age. It would make a lack of learning about their own culture, history and language. And the effects on their mental health is thought to be an issue as they could not speak in their native language, being far away from their family and friends.

Moreover, that the lack or shortage of Japanese language preparation is worried as a major problem for studying in Japan. While these students of this program have the opportunity to learn Japanese in their home countries, as they enter KOSEN immediately after graduating from junior high school, their Japanese skills are not enough to understand lectures delivered in Japanese. But most lectures at KOSEN are given in Japanese. Every student should take 16 classes a week in the first year, and the only three classes are delivered in English, Global Life science, Global Awareness and Oral communications. And the rest are basically given in Japanese. Therefore, various support systems have been designed to help them to study. While providing that support, it was also found necessary to provide specialized Japanese language education for science and mathematics subjects so that international students could understand the lectures.

Support system for Thai students

In the first year of this program, three students entered NIT Ibaraki College as first-grade students from three different Princess Chulabhorn Science High Schools in Thailand. Since they came to Japan without studying Japanese, they could not read or write even Hiragana and Katakana characters but just were able to greet and introduce themselves in Japanese in a fixed phrase. At first, they communicated with teachers and friends in English. The urgent task was to improve their Japanese skills. We set a deadline for their support for one year, and planned to remove special support when they move on to second grade. The support systems designed for Thai students are:

(1) Special curriculum, 13 hours of Japanese class a week
(2) Redesign of lectures
(3) Support during lecture by an assistant teacher
(4) Supplementary class after school
(5) Use of smartphone and voice translator

The outline of each support is shown below.

(1) Special curriculum, 13 hours of Japanese class a week

Table 1 shows the timetable for the first semester of 2018, when the first Thai students enrolled. They study Japanese in a separate classroom while Japanese students take national language, modern society, English grammar, geography, health, and art classes. These general education courses are supplemented by intensive courses of "World Affairs," "Japanese Affairs (1) to (5)," and "Japanology" classes held during spring and summer breaks. They also study with their Japanese classmates in the homeroom classroom or gymnasium during science and math courses, physical education, homerooms, and classes conducted in English.

Table 1. School timetable (1st semester of 2018)

	Mon.	Tue.	Wed.	Thu.	Fri.
1	Japanese	Japanese	Japanese	Japanese	English
2	Chemistry				Japanese
3		Global life science	Basic math 1	Basic math 2	
4	Physics	Japanese		Japanese	Basic math 1
5	Information literacy	Japanese	Engineering basic	Global awareness	
6				P.E.	P.E.
7	Basic math 2		Home room		Physics
8			Office hour		

(2) Redesign of lectures

The conventional lecture design has been reviewed and changed. The teachers in charge of the lesson add English into the materials such as slides, power point, mini quiz and handouts of the lesson. The Furigana telling how to read is added to difficult Kanji characters so that they can read and look up for the words in the dictionary. The explanation in Japanese consists a short, simple sentence. In the regular examination, we add English to the question sentence or give a Japanese-English word list to prevent the lack of Japanese ability affects their scores. They are allowed to answer in English to quizzes, reports, and regular examinations. These attempts are also a good opportunity for Japanese students to learn English technical terms and motivate them to learn in English.

We have also tried to increase the group works done by several students during the class. In addition to experiments and practical training, we created many opportunities to communicate with Japanese students solving exercises together, researching topics and giving poster presentations so that they are surrounded by casual Japanese. While there are many situations in which foreign students get nervous in the Japanese conversation, they demonstrated their abilities in fields they were good at, such as making presentations in English, and became accustomed to the class by being recognized and praised in the class.

(3) Support during lecture by an assistant teacher

The author, an assistant teacher for Thai students, attended the class of science and mathematics subjects (basic mathematics 1 and 2, physics, information literacy, chemistry and international creative engineering basic). The first-year students at Ibaraki KOSEN are not yet divided into specialized courses and all students take the same lecture. Three Thai students entered the same class to receive support together, and took a seat in a back row of the classroom at first. An assistant teacher accompanies them and explains the lecture in English or simple Japanese during the class.

(4) Supplementary class after school

We give supplementary classes for 2 to 5 hours a week after school. It includes a review of the day, preparation for the next class and discussion. They also learn the technical terms in Japanese and reading comprehension of the problem sentences. This class is held with only a small number of Thai students and an assistant teacher, focused on creating an atmosphere that is easy to ask questions and discuss. In order to relieve the tension of always being surrounded by Japanese students and having conversations in Japanese, the supplementary class is delivered in English and Thai. We talked about not only study but also everyday school life, dormitories, friends and casual Japanese expressions. The knowledge gained in this class have been applied to the next support.

(5) Use of smartphone and voice translator

Using smartphones during class is prohibited, but we have permitted the use of electronic dictionaries or smartphones with a dictionary function so that Thai students can immediately look up words they do not understand during the class. They mainly use the camera function to read Japanese words, but at the beginning of the semester, they could not use them because there were too many words to look up. However, the use of internet translation was effective at self-study. Kanji, which is a feature of Japanese, cannot be looked up in a dictionary without knowing how to read it, but they are able to look up words written in Kanji in textbooks using the camera import function of the translation application. We also tried to use a voice translator, but it was not suitable for use during class or supplementary lessons. But it was useful when explaining the medical condition at a school nurse’s office, when counselling and interviews in Japanese.

Interview with Thai students

While providing the support, I sometimes interviewed Thai students. At a year after admission, I asked them “Have you ever thought that you should have prepared something before you come to Japan?”, they answered “study more Japanese language”, “study Japanese”, “language”, and there was no mention of preparation in science and mathematics, culture and dairy life. In the interview in February, 10 months after admission, to a question “What is the biggest problem in your school life?”, they answered “Japanese language at study”, “I cannot understand what teachers say in Japanese”. Especially at the beginning of the first semester, they felt frustrated and stressed because they were not only confused by foreign life and climate changes that they were not accustomed to, but could not understand Japanese at all and could not take notes what teachers write down on a blackboard. Also, to the question "What did you do for understanding the lecture delivered in Japanese?", they answered "Guessing what it means from some words I can understand. As increasing the number of the words I can understand, it becomes clear."

A year after entering the school, I asked Thai students whether it was good for you to enter the same class as the Japanese from the beginning. They answered “I think join the class is good. Because it is good chance for me to use Japanese that I learned.”, “I think it’s good to join at first and study Japanese in the separated class because the class you don’t understand will push you to study what you don’t understand.” But some students answered “It would be better to understand Japanese first and then study about the topic.”, “I think it would be better taking only Japanese lessons first. But there was no problem to join the class, too.” According to the interviews we reaffirmed the importance of learning Japanese.

Effectiveness of learning technical terms

When the semester begins, they need to remember at least 20 to 60 new words for each subject a week. The assistant teacher receives the class materials from the class teacher in advance to select the technical terms to be learned during the week referring to the syllabus and textbook. A list of technical terms with the brief explanation is given them before the class. They repeatedly listen to the terms used in the lecture, and see them on a blackboard or slide during the class. In the subsequent supplementary class after school, they take a quiz to confirm technical terms as one of the reviews of the lecture that day. This cycle has been repeated to increase the vocabulary of technical terms. Initially, the term list and the confirmation test were done on paper, now we use the online teaching material creation site “Quizlet”. Quizlet is a site where you can easily create a flash card by online. You can share the created vocabulary cards with students and teachers, browse it on your smartphone and practice the vocabulary as many times as you like, and you can test your skills by yourself and check your proficiency level. It is provided to students according to the progress of the class. Figure 1 shows the image of the flash card.

Figure 1. Flash card of Quizlet

To confirm the effectiveness of learning technical terms in Japanese, the words used in the regular examination of physics, chemistry and mathematics are examined. Table 2 shows a list of words counted out of sentences used in the first-year regular examinations excluding postpositional particles and auxiliary verbs. (A) is a number of all words appeared in the regular examination and divided into (B) words learned in the supplementary class as technical terms, (C) words learned in the supplementary class that are not technical terms but often used in classes, and (D) others. (E) is the percentage of the sum of (B) and (C) as learned terms to (A) that is the all words used in the two examinations. The results show that in mathematics, regardless of the number of words used, more than 90% of the words used on the exam were previously learned through supplementary study by the assistant teacher. In physics, more than 80% of the questions were given with previously learned words, and in chemistry, 67-73% of the questions were given with previously learned words. Daily quizzes show a similar trend. The result that at least 67% of the words in the questions were previously learned shows that learning technical terms and commonly used words in lectures is effective enough to guess what is asked in the questions.

Table 2. Terms in the regular examination

	Physics		Chemistry		Math	
A	278	63	212	343	100	96
B	108	28	82	133	108	62
C	139	23	61	116	139	27
D	31	12	69	94	31	7
E	89	81	67	73	91	93

Discussion

As mentioned above, the most important and urgent task they should do after coming to Japan is to learn Japanese and increase the vocabulary.

There are merits to studying science and mathematics in foreign language for international students. In science and mathematics subjects, sentences in the textbook and workbook include various hints other than words. For example, a physical quantity is indicated by number and a unit, and it is possible to read what it represents from a typical symbol and a character of the quantity. Chemical formulas, element symbols, chemical reaction formulas, mathematical formulas, graphs, tables, and figures are also clue to understand what it means and what you are supposed to find and if there are any given preconditions or any special restrictions. However, the most useful is memorizing technical terms.

The vocabulary used in science and mathematics learning is very different from that used in everyday conversation. Comparing the vocabulary lists in Nishiyama's (2015) study, which were created from papers of the Nagoya University Engineering/Graduate School of Engineering, with the vocabulary list that would be acquired through university entrance exams and TOEIC study, it is clear that the overlapping frequent words are less than half of the total number of words. They learn basic words that used in dairy life in the Japanese class, but that is not enough to understand the lecture. Based on their interview, the level of understanding of Japanese they hear and see in the lesson will increase dramatically if they understand technical terms. Therefore, I tried to introduce the Japanese technical terms used in science and mathematics. However, it is difficult to learn all the vocabulary that appears in textbooks within a limited time, so it is necessary to introduce and absorb technical terms as the class progressed.

From the interviews with Thai students it is found that the knowledge required for each subject is different. They can presume what it means from numbers, formulas, diagrams, and graphs and understand how to solve exercises by a teacher showing them. There are relatively few technical terms, and you are able to use the textbooks written in English to keep up with the lessons. Physics and chemistry, on the other hand, often need verbal explanations to know the phenomena, it is difficult to understand the details in Japanese. In chemistry, when you enter high school, new concepts which you cannot see such as atomic model, reaction by electron transfer and ionization are introduced, and many new terms must be remembered. Kanji also makes learning more difficult. Many of the Thai students who enrolled in the first year of Kosen with this program commented that chemistry is difficult and said, "I wish I could have studied Japanese used in chemistry beforehand in Thailand."

Based on the results of the first term, we decided to focus on prior learning in Thailand from the second term. 12 candidates were selected in October, and after that, for about 6 months from October to April, Japanese language study was conducted by Thai teachers after school. In addition, online lessons by a teacher from KOSEN are also provided for conversation practice via Skype from Japan. 3rd and 4th term Thai students have started studying Japanese earlier.

Creation of terminology glossary

Since vocabulary used in daily life is given priority in the Japanese to be learned in advance, a collection of basic technical terms to be learned before coming to Japan was created as self-study materials provided by KOSEN. In addition to the 2,000 daily vocabulary words that must be memorized before entering the school, 50 words each in the three subjects of mathematics, physics, and chemistry were selected so as not to increase the learning burden. As the purpose of creating this material is to help students understand some of the lectures immediately after enrolment and to reduce the frustration of attending lectures given in Japanese, words were selected from the index pages of the textbooks actually

used by first-year students at Ibaraki KOSEN. There are around 300-500 words in the index for each subject.

The basic technical terms are selected by 150 words for mathematics, 350 words for chemistry, and 300 words for physics. For chemistry, 200 names of substance are added. In addition, words such as "height" and "speed," which are commonly used terms but frequently encountered in science and mathematics courses and essential for understanding lectures, were added, and from there the number of words was further reduced to 50 for each subject. The selection criteria are (1) frequently used, (2) used early in the first year of KOSEN, and (3) understandable by junior high school students. In physics, priority was given to units and physical quantities, while in chemistry, many familiar substance names were chosen. Figure 2 shows a part of the glossary.

Figure 2. Terminology glossary in Physics

物理用語 50（タイ日英）

【物理　ぶつり Physics】

	タイ語	日本語	ひらがな	English
1	หน่วย	単位	たんい	unit
2	มวล	質量	しつりょう	mass
3	ความยาว	長さ	ながさ	length
4	เวลา	時間	じかん	time
5	อุณหภูมิ	温度	おんど	temperature
6	ไฟฟ้า	電気	でんき	electricity
7	กระแสไฟฟ้า	電流	でんりゅう	electric current
8	แรงดันไฟฟ้า	電圧	でんあつ	voltage
9	ประจุ	電荷	でんか	charge
10	ความต้านทาน	抵抗	ていこう	resistance
11	อะตอม	原子	げんし	atom
12	อิเล็กตรอน	電子	でんし	electron
13	โปรตอน	陽子	ようし	proton
14	นิวตรอน	中性子	ちゅうせいし	neutron
15	นิวเคลียส	原子核	げんしかく	nucleus
16	คลื่น	波	なみ	wave
17	ความร้อน	熱	ねつ	heat
18	ของแข็ง	固体	こたい	solid
19	ของเหลว	液体	えきたい	liquid
20	ก๊าซ	気体	きたい	gas
21	การเคลื่อนไหว	運動	うんどう	motion
22	วัตถุ	物体	ぶったい	object
23	การทดลอง	実験	じっけん	experiment
24	แรงดึงดูด	重力	じゅうりょく	gravity

This glossary is created for the international students from Thailand to study by themselves before coming to Japan, the terms are written in Thai, Kanji notation, Hiragana reading, and English. For the "How to read formulas in Japanese" page in the appendix, formulas, Japanese readings, and English readings are provided so that students can practice
reading in Japanese. Since these formulas are only at a level that can be understood by junior high school students, a Thai translation is not provided. The translation of the technical terms into Thai was done by three Thai students who entered our school as the first students of this program. With their careful and enthusiastic cooperation, the "150 Basic Technical Terms for Thai Students" was completed after many revisions. This glossary is shared among the five KOSENs in Japan that accept Thai students, and is also provided to the Princess Chulabhorn Science High school in Thailand as an advance learning material prior to their arrival in Japan. We also provided Quizlet and held a terminology championship within PCSHS to motivate students to study in Japan while having fun. Memorizing technical terms and useful words commonly used in class has a great effect on foreign language class comprehension and examinations. Thai students in the first through fourth terms passed all subjects at the technical college in four years. However, one student from the first term was unable to continue his studies at KOSEN because his Japanese language skills did not improve and he could not pass the third level (N3) of the Japanese Language Proficiency Test. Since the number of students is still small, continuous verification is needed.

Summary

For the past four years, the author has been working with KOSEN teachers to provide learning support, counselling, and anxiety relief for younger Thai students. It is expected that we will be able to accept international students from other countries in lower grades, and students who do not understand the Japanese language that much. Therefore, it is necessary to generalize and expand support skills that do not depend on the country.

A future issue is the enhancement of pre-learning. In order to take care of international students with various Japanese language skills, it is necessary to develop and provide educational materials corresponding to each level of the learner. We will also establish an online support system using Skype, Google classroom and Quizlet, etc. so that we can support pre-learning when students are in Thailand and self-study after coming to Japan. It is possible to increase the number of accepted students and support the global learning of Kosen by fulfilling international student support. We continue to work with teachers and international students so that international students who come to Japan seeking the experience of learning and research at Kosen have a smooth and fulfilling Kosen school life.

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A SEMI-VIRTUAL JETBOT RACING COMPETITION IN AI AND ROBOTICS EDUCATION

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Abstract

An AI-based robot racing competition has been held in the joint laboratory course at National Institute of Technology, Kagawa College in Japan, and National Cheng Kung University in Taiwan. This laboratory course offers students the opportunity to have hands-on experience in AI and robotics. Due to the worldwide pandemic, all parts of the course must be conducted online. To organize a fair racing competition online, the race time must be measured as accurately as possible, even if the students are at different places. Therefore, several new attempts combining physical and virtual techniques have been made. The racetrack map is printed on paper to have an identical racetrack in both Japan and Taiwan. The students implement an AI-based robot autonomously driving on the physical racetrack for three laps. The students then film a video of it. The video is processed to determine the location of the robot and the race time. Finally, all the processed data are compared to determine the race results. In addition, a virtual racing video is created by integrating all the processed data.

Keywords: *artificial intelligence, deep neural networks, robotics, autonomous robot operation, international collaboration, joint lecture, online learning*

Introduction

In 2021, a laboratory course titled Introduction to Image Recognition Artificial Intelligence and Robotics Lab was jointly started by National Institute of Technology, Kagawa College (NITKC) in Japan and National Cheng Kung University (NCKU) in Taiwan. This course aimed to offer students the opportunity to have hands-on experience in the development of AI and robotics as well as international communication. The course was for 180 minutes per week spanning 16 weeks. 11 students from NITKC and 21 from NCKU enrolled in the course. To encourage communication between students from both Japan and Taiwan, the students were mixed and divided into 11 teams with two or three people per team. The students in the teams worked together for given tasks and competitions.

Figure 1 An AI-based robot JetBot used in this laboratory course.

The first half of the course focused on implementing image recognition AI using convolutional neural network (CNN) models. CNN is one of the key technologies in recent advances in AI (Goodfellow, 2016). An image classification competition was held during the course for the students to obtain practical techniques in CNN. The student teams designed and trained CNN models and competed for higher accuracy in a given classification task.

The second half of the course focused on implementing an autonomous driving robot using image recognition CNN models. An AI-based robot racing competition was held during the course. The teams trained their AI-based robot to follow the given racetrack and competed for the fastest time.

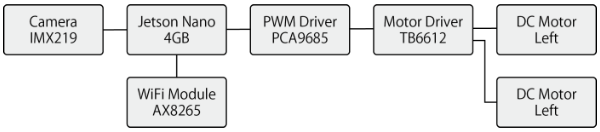

Figure 2 Block diagram of electronic components in the JetBot.

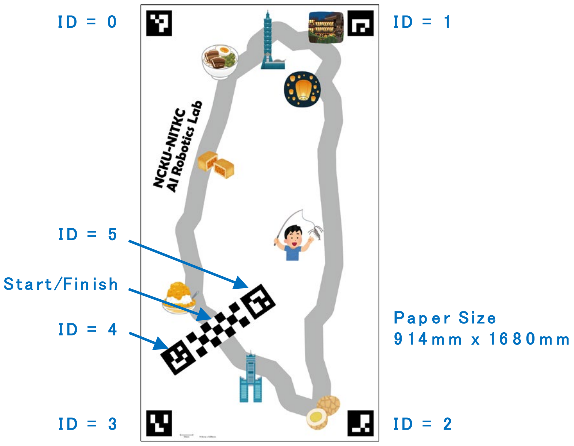

Figure 3 Racetrack map of the JetBot racing competition, which was designed to be printed on a paper with the size of 914 mm × 1680 mm.

Due to the COVID-19 pandemic, neither students nor teaching staff could travel between NITKC and NCKU in 2021. Therefore, all parts of the course had to be conducted online. Thanks to recent advances in online tools in conferencing and programming, the first half was done without any major technical problems. On the other hand, there were a couple of difficulties to overcome in the second half of the course because it deals with a robot in the physical world. To hold a racing competition, it is necessary to measure the race time of the robot as accurately as possible while students are at different places. This paper describes several new attempts to achieve as fair a racing competition as possible for this course.

Materials and Methods

The robot used in this laboratory course is the JetBot, shown in Figure 1. The JetBot is an open-source AI robot car based on an NVIDIA Jetson Nano. It is also equipped with an IMX219 camera, a PCA9685 PWM driver, a TB6612 motor driver, two DC motors, etc. The block diagram of the electronic components of the JetBot is shown in Figure 2.

Jetson Nano is a single board computer with a 4-core CPU and a 128-core GPU, which is suitable for embedded systems of AI applications (Jetson Nano Developer Kit, n.d.). The base software of the JetBot, including the operating system and some of the AI application tutorials, is available online (JetBot, n.d.).

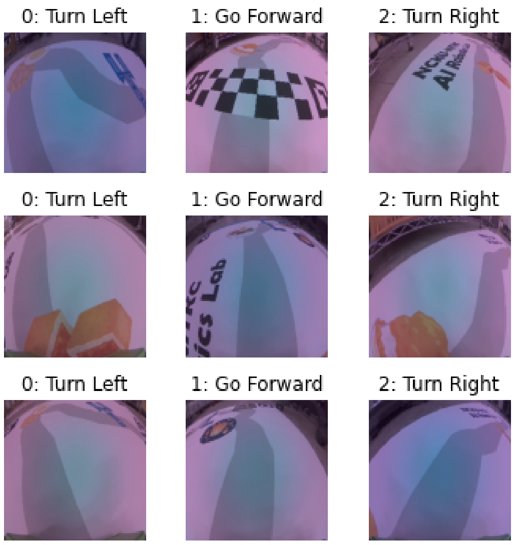

Figure 4 Examples of the custom training dataset for CNN models with a label of either "0: Turn Left, "1: Go Forward," or "2: Turn Right."

There is a tutorial project called "road following" in which the JetBot is made to follow the desired path. For the racing competition, the students used this project as a baseline.

Figure 3 shows the racetrack used in the racing competition. The shape of the racetrack is based on the coastline of Taiwan, and the JetBot must drive autonomously along the coastline for three laps in the competition. The racetrack map is designed to be printed on paper with the dimensions of 914 mm x 1680 mm. The paper with a width of 914 mm is A0+ standard paper, commonly used for poster presentations in academic conferences. Therefore, NITKC and NCKU can print out the racetrack map as many times as they want at their respective institutions. This is much easier than sending the racetrack maps from one place to another. As shown in Figure 3, six ArUco markers with IDs from 0 to 5 are also printed on the racetrack map. The ArUco markers are often used in computer vision applications to determine their locations. The ArUco markers can easily be detected using image processing libraries such as OpenCV ("Detection of ArUco Markers", n.d.). The ArUco makers with the ID 4 and 5 are used for determining the start/finish area, while the rest are used for the four paper corners.

AI-based autonomous driving in JetBot can be achieved by repeating processes of (1) taking an image from the camera, (2) making an inference with a pre-trained neural network model and the input image, and (3) controlling the motor output power relative to the result of the inference. The student teams first created a dataset for training a model. This was done by taking pictures with the onboard camera while the students manually navigated the JetBot on the racetrack. The pictures were labeled according to how they navigated

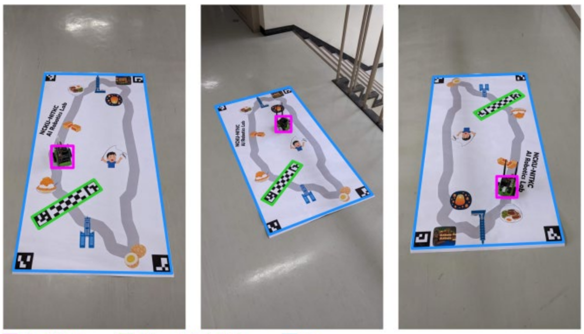

Figure 5 Examples of the data processing on the single video frames. The JetBot, the start/finish area, and the four paper corners are successfully detected in the pictures from any perspective.

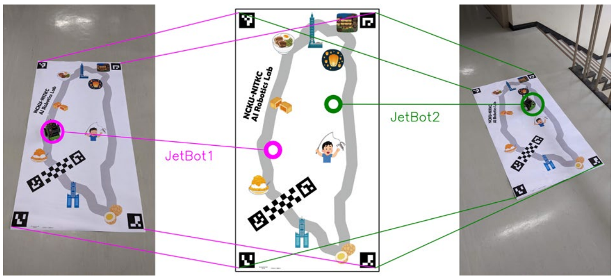

Figure 6 Examples of the transformation from single video frames taken from different perspectives to the standard geometry.

the JetBot. Figure 4 shows some examples of the training dataset. The pictures are labeled as one of three classes, either “0: Turn Left,” “1: Go Forward,” or “2: Turn Right”. Then the teams designed and trained CNN models with their custom dataset. However, the Jetson Nano is not an ideal option for training the CNN models because of its limited computation capability. Therefore, the teams used a web browser-based Python programming environment, Google Colaboratory. Recent AI development often requires a high-end GPU to accelerate neural network model training. However, setting up an appropriate GPU programming environment is sometimes complicated for beginners. On the other hand, Google Colaboratory offers a ready-to-use GPU environment for free, allowing beginners to start AI development more easily. The students already had enough experience in using Google Colaboratory during the first half of this course. After the training, the pre-trained CNN model was implemented on the JetBot for autonomous driving. The students repeated the above processes until they managed to drive the JetBot autonomously for three laps.

The racing competition was realized by combining physical and virtual parts. First, the student teams filmed a video of JetBot driving autonomously for three laps in the physical world. Then the video data was processed using the code provided by the authors. In the video processing, the coordinates of the JetBot, the start/finish area, and the four paper corners are determined in each frame. Figure 5 shows the results of the video processing performed on the single video frames. The JetBot, the start/finish area, and the four paper corners are successfully detected in the pictures from all perspectives. To detect the JetBot in the frames, a pre-trained object detection model, YOLOv4-tiny (Wang, 2021), is used. To prepare the pre-trained object detection model, the authors collected the JetBot videos from the students beforehand and created a custom JetBot dataset by annotating the video frames. Then the object detection model was trained with the dataset by the authors. It is essential to train the object detection model with the video data filmed under different conditions such as capturing devices, lighting, background, perspectives, etc. Otherwise, the pre-trained model overfits specific situations and cannot detect the JetBot very well filmed under different conditions. In the video processing, the number of laps is determined by counting the JetBot crossing the start/finish area, and the race time is determined by measuring the amount of time the JetBot needed to complete three laps.

By performing the video processing, a CSV data file that contains the time, the number of laps, the coordinates of JetBot, the start/finish area, and four paper corners is generated. Then the student teams submit their processed data to participate in the competition rounds.

The processed data submitted by the teams are integrated to create a virtual racing video. However, since the teams filmed the video from different perspectives, the data cannot be integrated directly. Therefore, all the data are transformed into a standard geometry using the perspective transformation method in OpenCV (“Geometric Image Transformations”, n.d.), as shown in Figure 6.

Races were held for three rounds in total spanning two weeks of the course. Each student team submitted their best time for each race, and the race result was determined by comparing all the submitted data. According to the race results, the points shown in Table 1 were given to the teams. The team that earned the highest total points won the overall competition.

Table 1. The points given to the teams in each race.

Race Result	Points
1st	10
2nd	9
3rd	8
4th	7
5th	6
6th -11th	5
DNF (Did Not Finish)	3
DNS (Did Not Start)	0

Results and Discussion

Figure 7 shows a snapshot of the virtual racing video created for one of the race rounds by using all the

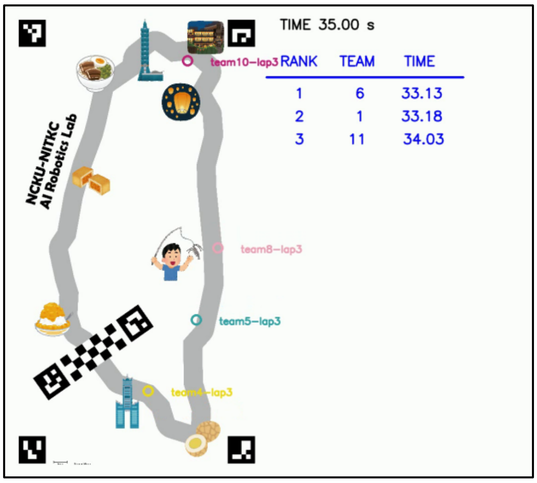

Figure 7 A snapshot of the virtual racing video created for one of the race rounds by merging and processing all the submitted data. The locations of the JetBots are indicated with the colored circles on the race course.

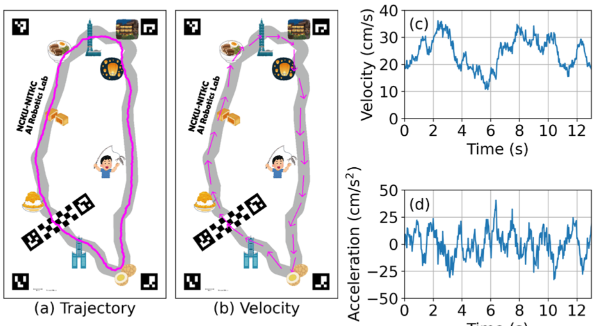

Figure 8 Examples of the data analysis (a) Trajectory of the JetBot for one lap, (b) velocity vectors, (c) time-dependent velocity, and (d) time-dependent acceleration.

submitted data. By transforming all the data into the standard geometry, as shown in Figure 6, all of the JetBots can be compared visually. The virtual racing video is not necessary to determine the race result because it can be done by comparing the race time saved in the submitted data. However, the authors consider that sharing the virtual racing video is important for the students to feel as if they are participating in a physical race competition, hopefully increasing their motivation. In addition, it also helps to hold a fair competition because the students can tell if there are any JetBots cheating during the race, for example, cutting corners.

Table 2 shows the results of race times over three rounds. All the teams have managed to drive their JetBot autonomously for three laps at least once. In addition, many have successfully improved the race time through the successive rounds. Several teams are labeled as DNS in Table 2 because they did not submit the CSV data by the deadline. They pursued reaching better results until the very last moment of the deadline. However, they did not have enough time to process the data. They could have earned at least three points for each race if they had submitted one of the processed data, even if it didn't complete three laps. Therefore, it was realized that time management is also essential for winning this competition.

Further data analysis can be done using the data processed by object detection and the perspective transformation. For example, Figure 8 (a) shows the trajectory of the JetBot visualized using the data of time-dependent coordinates. Then the time-dependent velocity and acceleration can be determined by simple calculations as shown in Figures 8 (c) and (d), respectively. Figure 8 (b) shows the velocity vectors of the JetBot at several points on the racetrack, indicating the JetBot runs faster where the arrows are longer. These visualized data might help the students to find room for improvement in their JetBot performance. In addition, it is a good opportunity for the students to practice data visualization techniques, which are essential for conducting any scientific research.

Table 2. Results of the race time of three race rounds in seconds.

Team No.	Round 1	Round 2	Round 3
1	31.63	33.18	32.62
2	50.38	DNS	25.86
3	DNS	DNS	43.64
4	61.83	36.01	DNF
5	47.20	38.53	45.60
6	DNS	33.13	30.38
7	DNS	DNS	54.67
8	47.87	39.87	31.87
9	34.40	DNS	35.21
10	DNS	43.57	DNS
11	38.62	34.03	36.30

Conclusion

A semi-virtual JetBot racing competition was held during the NITKC-NCKU joint laboratory course in 2021. To organize a fair racing competition online, several new attempts were made. To have an identical racetrack at both campuses, the racetrack map was made by printing it out on paper. The students participated in the competition by filming a video of the JetBot first. Then the video data was processed by the object detection model to identify the location of the JetBot. Finally, the race results were determined by comparing the submitted data.

Due to the worldwide pandemic, education styles at colleges have changed drastically. Today, many things can be done online, including classroom lectures and programming practice. However, it is still not easy for students to have hands-on experience with physical robotics online. The authors have demonstrated one of the ways to overcome this problem.

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POLYTECHNIC STUDENTS' ATTITUDES TOWARDS LEARNING MATHEMATICS IN A STUDENT-CENTRIC LEARNING ENVIRONMENT

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Abstract

Mathematics is taught to first-year polytechnic students studying various diplomas in engineering, science, information technology, and health and leisure. The students come from different educational backgrounds; as such, their attitudes towards mathematics may vary depending on their past experiences.

In this study, we aim to explore the attitude constructs representative of first-year polytechnic students' towards learning mathematics and investigate if there are any statistically significant relationships between them, in a student-centric learning environment.

The 21-item instrument used in this study is adapted from Khine et al. (2015) and included questions related to three factors: self-confidence, enjoyment, and perceived value of mathematics. The survey was administered to 465 students studying the first-year mathematics module. A Principal axis factor analysis of the items using Promax rotation, with Kaiser Normalization was carried out and four factors were identified which explained 59.82% of the total variance. The four factors are motivation, self-confidence, perceived value and enjoyment. Cronbach's alphas of the four factors ranged between .80 and .89, indicating high internal consistency reliabilities. Perceived value had the highest mean rating (M = 3.77 out of 5), followed by enjoyment (M = 3.67), self-confidence (M = 3.29) and motivation (M = 3.15).

Students find value in learning mathematics. However, due to their low level of motivation and confidence, they do not experience high levels of enjoyment. Educators should consider strategies to reinforce students' confidence in mathematics by ensuring that the challenges meet the abilities of students. This will also help in improving the motivation level of the students. To increase students' enjoyment in learning mathematics, students should be engaged with real-world issues and encouraged to have discussions about mathematical thinking.

The four factors are statistically significantly correlated with each other ($p < .001$). A high correlation between self-confidence and enjoyment is observed, which warrants further investigation. Future research can be conducted to investigate whether there are any statistically significant relationships between the factors of attitude towards learning mathematics and academic achievement in mathematics.

Keywords: *student-centric, PBL, mathematics, attitudes, polytechnic*

Introduction

Mathematics is offered to first-year polytechnic students studying various diplomas in engineering, science, information technology, and health and leisure. Problem Based Learning (PBL), a student-centric learning environment, is the dominant instructional strategy for this module. The students come from different educational backgrounds; as such their attitudes towards mathematics may vary depending on their past experiences.

The study of attitudes toward learning mathematics has been deliberated extensively in the literature. However, there is a plethora of different conceptual frameworks, theoretical perspectives, and measurements that have been suggested by educators, psychologists, and sociologists (Chaman, Beswick & Callingham, 2014; Lomas, Grootenboer & Attard 2012). Much of the studies have been carried out in non-PBL settings. For example, the study conducted by Di Martino and Zan (2010, 2015) examined a three-dimensional model for attitude (TMA) that shows interconnections between emotional dispositions towards mathematics, vision of mathematics, and perceived competence in mathematics. Furthermore, research by Khine, Al-Mutawah & Afari (2015), based on Trends in International Mathematics and Science Study (TIMSS) 2011, included affective constructs of enjoyment, self-confidence, and perceived value of mathematics to measure attitudes towards learning mathematics.

Self-efficacy in mathematics, which is one of the constructs of attitudes, has been studied in a PBL environment (Loo & Choi, 2013). However, there is a gap in the literature regarding the specific constructs of enjoyment, perceived value of mathematics, and self-confidence in mathematics, particularly when

mathematics is studied in a student-centric learning environment, which this study intends to explore.

Research Questions

The study was guided with the aim to explore the attitudes of polytechnic students toward learning mathematics in a student-centric learning environment. The following research questions (RQs) are proposed in this study:

- RQ1: What are the factors of attitude towards learning mathematics in a student-centric learning environment among first-year polytechnic students?
- RQ2: What are the reported mean ratings of the factors of attitude towards learning mathematics?
- RQ3: Are there any significant relationships between the factors of attitude towards learning mathematics?

Methods

Instrument

The 21-item instrument used in this study is adapted from Khine et al. (2015) and included questions related to three factors comprising confidence, enjoyment, and perceived value of mathematics. Students responded by indicating their level of agreement with each statement on a 5-point Likert scale.

The researchers sought expert opinions to check the content validity of the items. Consequently, one of the items, “Mathematics makes me confused and nervous” used by Khine et al. (2015) was separated into “Mathematics makes me confused” and “Mathematics makes me nervous”.

Ethics

Ethics approval for the research was sought from, and granted by the polytechnic ethics review committee. Students participating in the survey were assured of anonymity and all individual data were de-identified in the data set for analysis.

Sample

The survey for the main study was administered to 465 students studying first-year mathematics.

Results and Analysis

Statistical Packages for Social Sciences (SPSS) version 23.0 was used to analyse the collated quantitative data.

Descriptive Statistics

The descriptive statistical analyses show that the mean ratings of all the items ranged from 2.33 to 4.11. The standard deviations (SD) ranged from .84 to 1.32, and the skewness and kurtosis indices ranged from -.96 to .64 and -.91 to 1.35 respectively. Based on Kline’s (2005) recommendations of skewness and kurtosis (|3| and |10| respectively), the data in the study were considered to be univariate normal (Table 1).

Table 1.

Descriptive statistics of the items, N = 465

Item		M	SD	Skewness	Kurtosis
Q1.	I enjoy learning mathematics.	3.93	.96	-.94	.79
Q2.	I like mathematics	3.84	1.04	-.85	.37
Q3.	I would like a job that involves using mathematics.	3.15	1.07	-.25	-.41
Q4.	I learn things quickly in mathematics.	3.34	1.08	-.36	-.37
Q5.*	Mathematics is harder for me than any other subject.	2.75	1.22	.25	-.86
Q6.	My teacher and lecturer tell me I am good at mathematics.	3.14	.95	-.25	.13
Q7.	I need to do well in mathematics to get the job I want.	3.70	.97	-.56	.11

Q8.	I am good at working out difficult mathematics problems.	3.02	1.00	-.21	-.27
Q9.*	Mathematics is boring.	2.33	1.10	.64	-.21
Q10.	I need mathematics to learn other subjects.	3.55	.97	-.36	-.22
Q11.*	Mathematics is more difficult for me than for many of my classmates.	2.72	1.17	.26	-.69
Q12.	My teacher and lecturer think I can do well in mathematics.	3.54	.88	-.17	.14
Q13.	I think learning mathematics will help me in my daily life.	3.74	.95	-.69	.43
Q14.	Mathematics is one of my strengths.	3.31	1.25	-.32	-.90
Q15.	It is important to do well in mathematics.	4.11	.84	-.96	1.35
Q16.*	I wish I did not have to study mathematics.	2.58	1.32	.44	-.91
Q17.	I need to do well in mathematics to get into university.	4.01	.91	-.62	-.06
Q18.	I learn many interesting things in mathematics.	3.77	.95	-.68	.40
Q19.	I usually do well in mathematics.	3.40	1.07	-.44	-.22
Q20.*	Mathematics makes me confused.	3.02	1.15	-.02	-.76
Q21.*	Mathematics makes me nervous.	2.92	1.24	.04	-.88

* Items are reverse-coded

Inter-Item and Item-Total correlations

The Inter-Item correlations were satisfactory with values ranging from .04 to .86.

The Item-Total correlation for the item: "I need to do well in mathematics to get into university" had r = .22 and did not meet the requirement of r > .40 as suggested in the literature. The item was removed from further analysis as polytechnic students are primarily prepared for industry and this item may not be directly relevant to the cohort. The Item-Total correlations for all other items satisfied r > .40 requirements, with correlation values ranging from .41 to .80.

Exploratory Factor Analysis (EFA)

In order to answer RQ1, Exploratory Factor Analysis (EFA) was conducted with the data from 465 participants to determine the factors of attitude towards learning mathematics in a student-centric learning environment among first-year polytechnic students. A Principal axis factor analysis of the items using Promax rotation, with Kaiser Normalization was carried out. The Kaiser-Meyer-Olkin measure of sampling adequacy was .92, well above the recommended value of .60, and Bartlett's test of sphericity was significant (p <.001), confirming the factorability of the data.

One item ("I wish I did not have to study mathematics") was omitted because it was loaded on 2 factors with factor loading greater than .30. Before removing this item, the research team had checked the content and wordings to determine if the item could be interpreted in multiple ways by the respondents. As a result, 19 items were included in the second EFA. The visual inspection of the scree plot shown in Figure 1 suggested that four factors should be retained since the curve levels off beyond this. Eigenvalues greater than 1 and items with factor loadings of .40 or above were considered for analysis. Table 2 presents the factor loadings of the final 19 items, ranging between .41 and .88.

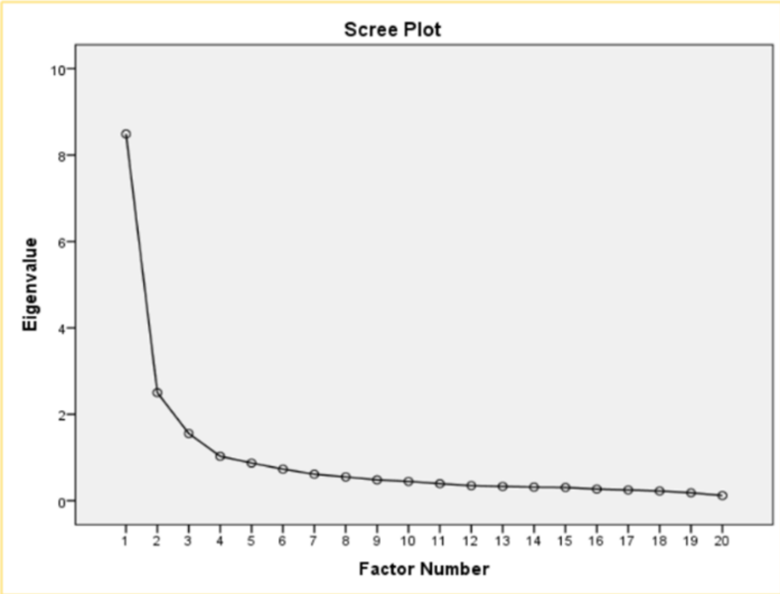

Figure 1: Scree Plot

Table 2.

Exploratory factor analyses results

Item		Factor Loading 1	2	3	4	Mean	SD
Q20.*	Mathematics makes me confused.	.88				3.02	1.15
Q21.*	Mathematics makes me nervous.	.85				2.92	1.24
Q11.*	Mathematics is more difficult for me than for many of my classmates.	.71				2.72	1.17
Q5.*	Mathematics is harder for me than any other subject.	.65				2.75	1.22
Q6.	My teacher and lecturer tell me I am good at mathematics.		.81			3.14	.95
Q8.	I am good at working out difficult mathematics problems.		.70			3.02	1.00
Q19.	I usually do well in mathematics.		.68			3.40	1.07
Q4.	I learn things quickly in mathematics.		.62			3.34	1.08
Q12.	My teacher and lecturer think I can do well in mathematics.		.58			3.54	.88
Q14.	Mathematics is one of my strengths.		.52			3.31	1.25
Q15.	It is important to do well in mathematics.			.74		4.11	.84
Q7.	I need to do well in mathematics to get the job I want.			.65		3.70	.97
Q10.	I need mathematics to learn other subjects.			.64		3.55	.97
Q13.	I think learning mathematics will help me in my daily life.			.62		3.74	.95
Q2.	I like mathematics.				.97	3.84	1.04
Q1.	I enjoy learning mathematics.				.82	3.93	.96
Q9.*	Mathematics is boring.				.59	2.33	1.10
Q3.	I would like a job that involves using mathematics.				.47	3.15	1.07
Q18.	I learn many interesting things in mathematics.				.41	3.77	.95
	% Variance	40.68	10.18	5.68	3.29		

* Items are reverse-coded

The result of the factor analysis yielded four factors which explained 59.82% of the total variance. The four factors are termed as: (1) motivation, (2) self-confidence, (3) perceived value and (4) enjoyment.

Descriptive statistics and reliabilities of the four factors are shown in Table 3. Perceived value had the highest mean rating (M = 3.77 out of 5), followed by enjoyment (M = 3.67), self-confidence (M = 3.29) and motivation (M = 3.15). Cronbach's alphas of the four factors were found to be ranging between .80 and .89, indicating high internal consistency reliabilities.

Table 3.

Descriptive statistics and reliabilities of the factors (N= 465)

	Factors	**No. of items**	**Descriptive Statistics**		**Cronbach's Alpha**
			M	**SD**	
(1)	Motivation	4	3.15	.99	.85
(2)	Self-confidence	6	3.29	.83	.89
(3)	Perceived value	4	3.77	.73	.80
(4)	Enjoyment	5	3.67	.81	.85

In order to answer RQ3, correlation analysis was conducted on the four identified factors. Table 4 shows the correlations among the four identified factors. It is noted that all factors are statistically significantly correlated to each other.

Table 4.

Correlations among the factors (N= 465)

	Factors	**Correlation**			
		(1)	**(2)**	**(3)**	**(4)**
(1)	Motivation	–	.56**	.13**	.55**
(2)	Self-confidence		–	.40**	.71**
(3)	Perceived value			–	.49**
(4)	Enjoyment	–	. –	–	–

Note: ** $p < .001$

Discussion

The purpose of this paper was to report the factors and the mean ratings of attitude toward learning mathematics in a student-centric learning environment among first-year students and to establish whether there were any significant correlations between the factors.

First, descriptive statistics of the items were obtained to get a sense of the data. Kurtosis and skewness values were within the recommended levels, implying the data in the study was univariate normal.

Next, to answer RQ1, EFA was carried out. Four factors of attitude towards learning mathematics were identified, namely: motivation, self-confidence,

perceived value and enjoyment. The motivation factor accounted for the highest proportion of variance with 40.68%. This was followed by, to a lesser degree, self-confidence, perceived value and enjoyment which explained an additional 10.18%, 5.68% and 3.29% respectively. These factors accounted for 59.82% of the total variance.

To answer RQ2, descriptive statistics of the factors were found. Perceived value had the highest mean rating followed by enjoyment, self-confidence and motivation. Students with high self-confidence enjoy learning mathematics. Students find value (M = 3.77, SD = .73) in learning mathematics. However, due to their low self-confidence (M = 3.29, SD = .83) they do not experience high levels of enjoyment (M = 3.67, SD = .81). Also, student motivation (M = 3.15, SD = .99) is low. Educators should consider strategies to reinforce students' confidence in mathematics by ensuring that the challenges meet the abilities of students. This will also assist in improving the motivation level of the students. To increase students' enjoyment in learning mathematics, students should be engaged with real-world issues and encouraged to have discussions about mathematical thinking (Fernandez, Llinares & Valls, 2012).

Finally, to answer RQ3, correlation analysis was carried out. All four factors of attitudes towards learning mathematics were statistically significantly correlated to each other. There is a high correlation between self-confidence and enjoyment (Table 4).

Limitations and Further Research

This study is not without limitations. First, this study only used students in a particular polytechnic in Singapore, which may not be representative of the population of students in other higher educational institutions in Singapore. As a result, the generalisation of the results of this study needs to be interpreted with caution. Multiple samples and analyses of students across different cohorts should be considered. Second, the four factors of attitudes towards learning mathematics accounted for 59.82% of the total variance. Further studies could consider including more variables. Also, future studies could investigate whether there are any significant relationships between the factors of attitude towards learning mathematics and academic achievement in mathematics.

Conclusion

The results of the study provide useful information on students' attitudes towards learning mathematics in a first-year mathematics module in a student-centric learning environment. Four factors of attitude towards learning mathematics are identified: motivation, self-confidence, perceived value and enjoyment. Perceived value has the highest mean rating among the four factors. All factors are statistically significantly correlated with each other.

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Facilitating academic learning, civic learning and personal growth in STEM education through electronic service-learning

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Abstract

Ngee Ann Polytechnic (NP) adopted Service-Learning (S-L) as its signature pedagogy in 2016. All NP students take at least one module with a Service-Learning project in which they apply their course skills and knowledge to address community needs.

In October 2021 semester, electronic Service-Learning (eS-L) was used in the design and delivery of a number of modules within NP science, technology, engineering and mathematics (STEM) diploma programmes. This study examines the impact of eS-L on student learning outcomes including academic learning, civic learning and personal growth in six STEM modules in NP School of Engineering (SoE), School of Health Sciences (HS) and School of Life Sciences and Chemical Technology (LSCT).

In this study, students across the six modules completed a survey before and another after their eS-L experience. The study adopts a mixed method using within-subjects design to triangulate quantitative survey results with qualitative findings collected through student interviews. The 9-item pre-eS-L survey measured civic learning and the 39-item post-S-L survey measured civic learning, academic learning, and eS-L elements including connection between service and learning, critical reflection, community voice, meaningful service, dialogue with diverse others, reciprocal relationships, student voice and technology effectiveness.

At the start of the module, pre-eS-L activities introduce students to the projects and communities they will be working with. Throughout the semester, students plan and deliver services to the communities and/or community organisations using the knowledge and skills learnt from the modules. Before, during and after the eS-L project, students were prompted to reflect on academic learning, civic learning and personal growth based on the Describe, Examine, Articulate Learning (DEAL) model (Ash & Clayton, 2009).

Results suggested the potential value of eS-L in facilitating holistic development in academic learning, civic learning and personal growth in STEM education.

Keywords: *service-learning, electronic service-learning, ICT tool, learning outcome*

Introduction and Purpose

Service-Learning (S-L) has been adopted as Ngee Ann Polytechnic's (NP) signature pedagogy and since 2016, all students enrolled would have at least one S-L module experience during their course of study at NP. Institutionally, NP has adopted Bringle and Clayton's (2012) definition of S-L as a "course-based, credit-bearing educational experience in which students (a) participate in mutually identified and organized service activities that benefit the community, and (b) reflect on the service activity in such a way as to gain further understanding of course content, a broader appreciation of the discipline, and an enhanced sense of personal values and civic responsibility".

The positive impact of S-L on students' learning has been widely documented (Yorio & Ye, 2012). In science, technology, engineering and mathematics (STEM) education, S-L has been suggested to facilitate students' learning on delivering professional work responsibly in the workplace and in community service (Pritchard, 2000; Tsang, 2000). A few innovative institutions and programmes have adopted S-L throughout the curriculum; however, studies on S-L design and implementation in STEM education are relatively few compared to other areas of study (Scherrer & Sharpe, 2020).

In response to the COVID-19 pandemic, NP switched to home-based learning (HBL) in April 2020 semester, and lecturers had to pivot their face-to-face lessons to online HBL. S-L modules had to be redesigned into

Electronic Service-Learning (eS-L) modules, which posed a unique challenge as conventional S-L design typically involves face-to-face interactions and services for community partners. The design and implementation of eS-L is not a simple relocation of existing conventional face-to-face S-L into an online platform (Bringle & Clayton, 2020). Instead, these demands deliberate and careful integration of S-L with technologies and proper attention to sound pedagogical guidelines for module redesign to achieve the learning outcomes.

This study takes advantage of the natural experiment that presented itself to NP and investigates the impact of eS-L on student learning outcomes including academic learning, civic learning and personal growth across six STEM modules in NP School of Engineering (SoE), School of Health Sciences (HS) and School of Life Sciences and Chemical Technology (LSCT). The study also looks into the extent to which empirically supported S-L elements are applicable in eS-L context, and examines how technology element influence the design and outcomes of eS-L.

Theoretical Background

Service-Learning

S-L is an integration of classroom-based learning activities and community-based services (Furco & Norvell, 2019). S-L provides a unique educational experience for students to engage with these experiences, apply academic knowledge and skills to benefit the community and reflect on their experiences to learn about social issues and for personal growth in terms of character development and career preparation (Clayton & Ash, 2004).

The impact of S-L on students' academic and critical thinking, civic learning and personal growth and/or professional development have been well-documented in literature (Austin, et al., 2006; Conway et al., 2009; Eyler & Giles, 1999). Celio et al.'s (2011) meta-analysis of over 11,800 precollegiate and collegiate students across 62 S-L studies found improvements for attitudes toward self, learning and school, civic engagement, social skills and academic performance. Other meta-analyses found similar favourable outcomes for understanding of social issues, personal insight, academic and cognitive development, as well as social and citizenship domains (Conway et al., 2009; Yorio & Ye, 2012).

Specific to the Singapore context, Choo et al. (2019) found significant improvement in perceived civic outcomes among polytechnic students in S-L modules compared to those in non-S-L condition, as well as favourable outcomes in academic connection, career preparation and personal and interpersonal development following S-L.

There are four categories of S-L service activities/projects: (a) direct service, (b) indirect service, (c) research, and (d) advocacy (Bringle et al., 2016; Kaye, 2010). In direct service, students engage in person-to-person service projects in which the students' service directly impacts individuals who receive the service from the students. Indirect service involves working with organisations, groups or offices on projects that benefit the community or environment, but not directly with specific individuals. Research activities involve the collection and presentation of information on areas of need/interest. Lastly, advocacy service educates the public to enhance awareness and action on issues in the community. Table 1 gives some examples of service activities/projects in each category.

Table 1. Examples of Service Activities (Kaye, 2010)

Category	Service Activities
Direct	• Tutoring at-risk youths • Giving presentation on drug prevention to youths
Indirect	• Creating communication contents (brochures, videos) for partner organisation • Organising crowdfunding or donation drives
Research	• Conducting longitudinal study on water or air quality and presenting the results • Creating and implementing a survey and generating a report
Advocacy	• Conducting public campaigns on social issues in the community • Working with governmental bodies to promote awareness on local issues

Electronic Service-Learning

Conventionally, both course instruction and S-L experience occur in a face-to-face environment. However, the increased popularity of online education globally and the current COVID-19 pandemic have prompted a revision of the education landscape. With the advent of home-based online learning, Singapore's Ministry of Education is reviewing how to "blend" classroom and digital learning to "harness the best of both worlds" (Ang, 2020). Bringle and Clayton (2020) emphasized that when integrating S-L and online learning, it is crucial to identify and merge the distinctive strengths of each pedagogy to achieve the learning goals. eS-L may be an attractive alternative to accommodate circumstances requiring online learning and reduced physical social interaction.

Waldner et al. (2012) posited four types of eS-L (Table 2) with varying extent to which course instruction and S-L experience are conducted online or onsite. The feasibility of designing and implementing eS-L depends largely on the nature of the course/module and S-L project. For example, while all NP course instructions were moved online in view of COVID-19, online lessons could not replace practical lessons in laboratories, clinical facilities and studios. Similarly, it may be easier

to redesign S-L service projects in indirect, research, or advocacy categories to be conducted and delivered online.

Table 2. Types of eS-L (Waldner et al., 2012)

	Course Instruction	S-L Experience
Type 1 (hybrid)	100% online	100% onsite
Type 2 (hybrid)	100% onsite	100% online
Type 3 (hybrid)	blended	blended
Type 4 (extreme)	100% online	100% online

eS-L can potentially overcome the geographical restrictions faced by conventional S-L (Waldner et al., 2012) through the use of online communication tools and makes learning more flexible as students can gain access to online materials and instructions at their convenience (Marcus et al., 2019). eS-L is a powerful method to promote interaction (e.g., student-student, student-instructor, student-community partner) and engagement which are perceived to be lacking in typical online learning (Gaytan & McEwen, 2007; Hill et al., 2009; Muirhead, 2004; Swan, 2002; Waldner et al., 2012). Moreover, eS-L is capable of engaging non-typical populations, which is a challenge in conventional S-L, such as the disabled (Malvey et al., 2005), individuals who are introverted (Waldner et al., 2012), and those who do not live near their schools (Strait & Hamerlinck, 2010).

While there is considerably little research on eS-L, available ones have generally pointed to similar learning outcomes as conventional face-to-face S-L (McGorry, 2012; Waldner et al., 2010). Marcus et al. (2019) analysed the reflections of students who participated in a Type 3 eS-L, where both course instruction and S-L experience are blended between onsite and online, and found that they showed greatest enhancement in global citizen skill, followed by scholarship and adaptability skills. Although teamwork skill is a common learning outcome of conventional S-L, it was less reported in this study. Most students were followers and few assumed leadership positions. The integration of the online platform was also well-received as students felt that it helped them monitor their learning journeys.

Type 4 eS-L, where both course instruction and S-L experience are fully online, has shown to be feasible among individuals in either a public health policy or a marketing management course. These fully online S-L courses met all the criteria for feasibility including product completion, client satisfaction, student satisfaction, interaction and skill-building (Waldner et al., 2010). When the learning outcomes (practical and interpersonal skills, citizenship and personal responsibility) between conventional S-L and Type 4 eS-L pedagogies were compared for both marketing strategy and marketing research courses, no significant differences were found (McGorry, 2012).

Design and Implementation of S-L and eS-L Modules

S-L Quality Assessment Tool (SLQAT) was designed to evaluate, design and implement S-L modules (Furco et. al., 2018). SLQAT tool incorporates 28 "essential elements" from research on high quality S-L and are organised into five dimensions (i.e., Course Design, Learning, Student, Instructor and Community Partner & Partnership). The Center for Service and Learning at Indiana University-Purdue University, Indianapolis has also developed a Taxonomy for S-L modules that supports fidelity and quality by identifying six crucial attributes of S-L courses (Hahn et. al., 2016). In the local context, Choo et al.'s (2019) study of NP students also indicated the importance of students' perceived impact of S-L, preparedness for S-L, quality of reflection prompts and amount of interaction with the community in designing and implementing S-L. These elements were reviewed, piloted, and narrowed down by NP's Office of Service-Learning (OSL) to the current list (Table 3). The descriptive text helps raters decide if the element is present, and if so, how well it is implemented.

Table 3. NP OSL's S-L Elements Adopted from SLQAT and IUPUI S-L Taxonomy

S-L Element	Descriptive Attribute
Connection between service and learning	There are evidences of how the service activities and the module's learning goals relate to each other.
Critical reflection	The module includes relevant critical reflection activities intended to foster connections between module content and service activities.
Dialogue with diverse others	Dialogue with others across differences (e.g., race, ethnicity, age, language, religion, social-economic status) occurs regularly.
Meaningful service	Service activities are based on a clear, meaningful, community-identified issue/need. Service activities help meet the needs that the community finds important.
Reciprocal relationship	Reciprocal partnerships and processes shape the community activities, module design, and community outcomes. There is mutual benefit for both community organisation and school.
Community voice	Community partner plays a co-educator role and provides input in shaping the S-L experience.
Student voice	Module incorporates opportunities/activities for student voice (e.g. autonomy, choice, creativity, leadership, influence) in the S-L experience.

In the context of eS-L, there are other additional factors crucial and unique to its success besides the seven elements adopted by NP OSL. In this study, Technology Effectiveness is added as an eS-L element to capture the significance and impact of technological tools.

eS-L requires technical capability and training of students in view of the need to use various technological platforms/tools to plan and implement S-L online. Malvey et al. (2006) highlighted the need to assess students' technological skills, inform them of the software requirements and expose them to online learning to mitigate cognitive overload. Others suggested that faculty have the responsibility to bridge synchronous and asynchronous communications in eS-L to promote inclusivity and systematic tracking (Waldner et al., 2012). Community partners chosen should be receptive towards technologies (Stoecker et al., 2008; Waldner et al., 2010). Clearly, training should be extended to both faculty (Strait & Sauer, 2004) and community partners (Seifer & Mihalynuk, 2005). Faculty and community partners should also conduct trial runs prior to real sessions to ensure quality of eS-L (Waldner et al., 2012).

Setting clear communication expectations is critical to avoid disengagement and confusion among the different parties. Hunter (2007) and Malvey et al. (2006) suggested "memorandums of understanding" among students, faculty and community partners to ensure commitment for the project collaboration. This can guide faculty on active engagement with students and provision of sufficient feedback to students, which are vital in eS-L as it lacks the promptness of face-to-face learning (Hunter, 2007; Tabor, 2007).

When communicating online, the absence of nonverbal cues can interfere with communication effectiveness and is associated with feelings of disconnectedness (Lapidot-Lefler & Barak, 2012). It is often hard for users to decipher each other's nonverbal body language and unspoken cues in virtual communication (Guthrie & McCracken, 2010). As such, students should be cautioned about inappropriate online communications as such toxic disinhibition effect can affect relationships with community partners (Shah et al., 2018; Suler, 2004). eS-L modules should deliberately be designed to promote active participation among all parties. This is especially so for Type 4 eS-L where synchronous interaction may be less frequent (Waldner et al., 2010) and interaction can be more truncated (Bringle & Clayton, 2020).

While both S-L and eS-L emphasise the importance of building reciprocal relationships with community partners, eS-L may have to rely on online interactions. At the beginning of the course, a community partner "reveal" (e.g., video teleconferencing) helps to promote active communication and engagement between students and community partners. Students have reflected that a real-time chat or a physical meeting was crucial in building relationships and for them to understand the rationale and issues being tackled in the various projects (McGorry, 2006).

Methods

Participants

Students across six eS-L modules from three NP STEM schools in October 2021 semester were invited to participate in this study. A total of 160 students completed one survey before and another survey after their eS-L experience. Among this group of participants, 11 students further took part in focus group interviews which were conducted online.

The modules and eS-L projects are summarised in Table 4. In October 2021 semester, the COVID-19 pandemic situation in Singapore was such that face-to-face lessons could resume partially in NP with Safe Management Measures (SMM). However, community visits were not yet possible and hence all community interaction and activities remain online. As such, all six modules were designed and conducted as eS-L Hybrid Type 2 in October 2021 semester, with lessons conducted onsite and service delivery online.

Table 4. eS-L Modules Included in This Study

Module Name (Diploma/ Programme, Year of Study)	**Service Category**	**S-L Project**
Integrated Real-world Project 2 (Common Engineering Programme, Electrical & Electronic Track, year 1)	Indirect	Students design smart solutions to improve safety on shared paths (pedestrians, bicycles, mobility devices etc.) and present their proposals online
Integrated Real-world Project 2 (Common Engineering Programme, Mechanical Track, year 1)	Direct	Students conduct virtual workshops for children to build their own STEM toys and learn about the science principles
Gerontology & Community Nursing (Diploma in Nursing, year 1)	Advocacy	Students conduct online sharing sessions with community members to promote awareness of active ageing and preventive disease management
Singapore & World Issues (Diploma in Nursing, year 2)	Indirect & Research	Students conduct online interviews with migrant workers and partner organisation staff on the impact COVID-

		19 had on migrant workers' mental health, then create infographics on mental health awareness and helpline resources to be distributed in various migrant workers' dormitories.
Environmental Health & Safety (Diploma in Chemical & Biomolecular Engineering, year 2)	Research	Students perform testing of water samples to gather data on coastal water pollutants and present their findings online
Active, Beautiful & Clean (ABC) Waters Management (Diploma in Environmental & Water Technology, year 2)	Indirect	Students develop app-based educational guides for visitors to various nature trails in Singapore

Research Design

This study uses a mixed method to triangulate quantitative survey results with qualitative interview findings. A within-subjects design is employed to examine the students' academic learning as well as the change in students' civic learning scores before and after eS-L. Quantitative analysis of the scores for academic and civic learning, as well as correlational analysis of the relationships between eS-L elements and outcomes, were conducted. In addition, qualitative data was collected through student interviews to gather insights that may not be obtained through standardised scales.

The 9-item pre-eS-L survey measured civic learning outcomes, while the 39-item post-eS-L survey measured civic learning and academic learning outcomes as well as eS-L elements including connection between service and learning, critical reflection, community voice, meaningful service, dialogue with diverse others, reciprocal relationships, student voice, and technology effectiveness. These scales are based on previous S-L research in NP by Choo et al. (2019) which have high internal consistency and have produced meaningful results. The responses for the survey items were based on a five-point Likert scale, ranging from (1) Strongly Disagree to (5) Strongly Agree.

For the student interviews, this study adopted the sampling method used by Choo et al. (2019) to produce theoretically and practically meaningful findings. Specifically, student interviewees were purposefully sampled to select those with low and high change scores in civic learning on the surveys, which would ensure representations of students who reported low or high eS-L impact and facilitate triangulation with the quantitative data. The interview questions focused on the students' perspectives on the impact of eS-L on academic learning, civic learning and personal growth, as well as the eS-L design and implementation elements.

eS-L Design and Implementation

At the start of the semester, students went through pre-service activities in their respective modules where lecturers briefed them about S-L principles and purpose and the service projects they would undertake with the community partners. Pre-service activities aimed to increase the students' understanding of the community's issues and strengths as well as administrative and preparatory information about the service project (e.g., policies, rules, ethical issues, safety). Students then embarked in the various service projects as listed above in Table 4. Towards the end of the semester, post-service activities required students to present the required deliverables and evaluate the whole process on how the service activities relate to the eS-L learning outcomes.

Throughout the entire semester, reflection activities took place pre-, during, and post-service. Lecturers used reflection prompts based on the DEAL – Describe, Examine, Articulate Learning – model (Ash & Clayton, 2009). In particular, four key questions were asked in post-service reflection: (a) What did I learn?; (b) How did I learn it?; (c) Why does this learning matter?; and (d) What will I do in light of my learning? Students reflect on these questions, guided by reflection prompts provided by lecturers for each of the academic learning, civic learning and personal growth learning outcomes.

Results and Discussion

Civic Learning

Based on pre-eS-L and post-eS-L survey data, paired sample t-test analysis reveals that students had significantly higher civic learning outcomes after eS-L ($M = 3.94$, $SD = 0.55$) than before eS-L ($M = 3.69$, $SD = 0.50$), $t(159) = 6.35$, $p < .01$. This suggests that the eS-L experience was effective in increasing students' civic awareness and responsibility.

During the interviews, students reflected that eS-L experiences have enhanced their civic learning. Some students cited how they have become more aware of certain environmental and social issues, such as ecological impacts of plastic trash, diverse perspectives of shared path users, challenges faced by children from low-income families during COVID-19 circuit breaker. Some students also expressed increased desire and commitment to take actions, such as being more understanding and empathetic towards people with disabilities or mental health conditions, making time to volunteer, picking up trash, being responsible when cycling/walking. On the other hand, some students remarked that interacting online with the community felt

less natural than meeting face-to-face. Some reflected that they have not understood enough about the issues and needs of the community and would have preferred to have more opportunities for interaction.

Academic Learning

Post-eS-L survey data indicates that students' academic learning outcomes (M = 4.00, SD = 0.70) were significantly higher than the neutral score of 3. This suggests that eS-L experience had been effective in improving students' academic learning from the modules.

Students expressed in general that the eS-L experience has helped put their academic contents into real-world contexts. They were able to apply their knowledge and skills in connection with existing issues and needs in the community, for example how microcontroller technology can help improve the safety of shared paths, how a particular park/waterway help retain water and prevent floods.

Personal Growth

Findings on personal growth were collected through the interviews, in the context of values and character development and professional preparation. Students reported that they developed values such as respect, gratitude, compassion, responsibility and discipline. COVID-19 Safe Management Measures made it harder to work on group projects, but students also learnt the values of resilience and patience. They also developed soft skills such as project management, time management, communication skills including active listening and interviewing skills. Some students reflected that they picked up professional technical skills through their eS-L projects such as report writing, media editing and web/app development skills. Several students discovered their strengths and preferences such as hands-on, leadership, logical thinking, and came to realise possible career paths that they could explore, such as professions that require meticulous reporting, working outdoors, working with children.

Correlations between eS-L Elements and Learning Outcomes

Table 5 summarises the correlation between eS-L design and implementation elements with academic learning and civic learning outcomes. Civic learning outcomes are presented as the difference between pre- and post-eS-L civic learning scores.

Table 5. Correlation between eS-L elements with academic learning (AL) and civic learning (ΔCL) outcomes

eS-L Elements	**AL**	**ΔCL**
Connection between service & learning	.79*	.35*
Critical reflection	.68*	.20**
Community voice	.60*	.30*
Meaningful service	.65*	.36*
Dialogue with diverse others	.52*	.32*
Reciprocal relationship	.63*	.37*
Student voice	.62*	.36*
Technology effectiveness	.68*	.31*

* $p < .001$, ** $p < 0.05$

As shown in Table 5, all eight eS-L elements show positive and significant relationships with the academic learning and civic learning outcomes. From this result, it can be concluded that all eight elements are necessary to be considered in the design and implementation of eS-L modules. The additional eS-L element Technology Effectiveness is shown to be on par with conventional S-L elements. This suggests the importance of selecting and using suitable technological tools to deliver course content to students and to serve as eS-L engagement platform between students and community partners/members. Students, lecturers and community partners should also be prepared and capable to utilize the technological tools. In addition, eS-L design should intentionally promote regular and clear online communication and active engagement among students, lecturers and community partner, keeping in mind the lack/absence of nonverbal communication cues in online communication.

In general, the correlation between eS-L elements and academic learning outcomes are higher than the correlation between eS-L elements and civic learning outcomes. This suggests stronger relationships between eS-L elements and academic learning. One possible reason for this could be that students understand and appreciate discipline-specific academic learning objectives more clearly than civic learning objectives. In addition, it can be inferred that the eS-L projects (Table 4) had been designed such that they are constructively aligned with the academic contents of the modules.

One possible future improvement related to civic learning could be to improve the clarity of civic learning objectives for students. Lecturers can also look into connecting eS-L elements more strongly to civic learning objectives when these elements appear before, during and after the eS-L experiences. In particular, the elements of critical reflection and community voice may need to be more purposefully linked with civic learning objectives

During the interviews, students reflected that they have relatively stronger voice and freedom in managing and executing their eS-L project, compared to conventional S-L projects. As a result, students strengthened their communication, teamwork, problem solving and conflict resolution skills, and even picked up digital skills such as media production and editing. On the other hand, some students expressed that they would have preferred more guidance and less open scope along the way. Students also reflected that the opportunities to

hear from and serve the community meaningfully had made them more aware of their future roles as professionals in their disciplines.

Conclusions

S-L as a high impact pedagogy (Kuh & Schneider, 2008) has been adopted as NP's signature pedagogy in 2016. With the advances in educational technology and landscape shift towards online learning, this study investigates the impact of eS-L on student learning outcomes across six STEM modules in NP.

The results of the study show that eS-L is effective in achieving academic learning, civic learning and personal growth outcomes in STEM modules. The results also show that eight eS-L elements are crucial in the design and implementation of eS-L modules in order to achieve student learning outcomes. These learning outcomes will in turn contribute to the holistic development of NP students.

The findings of this study also suggest that eS-L module design and instructor delivery and facilitation greatly impact students' eS-L experience. As such, faculty development and support are crucial to ensure that student learning outcomes are achieved through eS-L modules.

Education technology and online learning will continue to shape the future of education, where eS-L and face-to-face S-L will continue to have their places in the education landscape. eS-L overcomes the constraints of geographical boundaries and may help to ensure consistency in access, service delivery and assessment for large cohorts of students.

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Report on Selection of Applicable Research Projects that Respect the Will and Intentions of Students, and Their Activities and Student Education

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Abstract

The research theme of our laboratory is based on the hobbies and interests of the KOSEN student members to which we belong, and we are considering the versatility of those subjects. For example, one of the members is interested in sleep because his family has a sleep disorder. Therefore, he has developed a device to measure the respiratory rate during sleep, and is working on solving this problem with the goal of visualizing the respiratory state by grasping the shallowness and quality of sleep. The device can also count breathing rates and track breathing depth and rhythm. This device is expected to be used not only for sleep apnea syndrome, but also for understanding the prevalence and symptoms of orthostatic hypotension and age-related hypotension in children. Another student's hobby is fishing. He has a deep interest and knowledge of fish. He is considering classification using images of fresh fish. In our research, we use a technique that combines basic statistical analysis with signal processing theory and deep learning. We intend to apply this method not only to identify the type of fish, but also to discriminate between male and female fish, class discrimination, agricultural product discrimination, and factory product inspection. In addition, our research is conducted in collaboration with fields other than mechanical engineering, which is our specialty. For this reason, students attend research conferences on electricity and information, conduct hearings with experts and fishery cooperatives, and exchange opinions with research advisors and faculty members at foreign universities. In this way, our laboratory students have the opportunity to communicate with people outside the university and laboratory and experience different situations. And the students in our laboratory can develop into research with applied value through their own interests and foster their positive attitude. This paper outlines and reports on the research and gives concrete examples of how student interests and interests are utilized in our research.

Keywords: s*ignal processing, multivariate analysis, wavelet transform, sleep apnea syndrome, image recognition*

1. Introduction

There are many examples of KOSEN students whose research subjects are hobbies and interests. However, many of these research subjects are targeted only at specific subjects and are not versatile. In our laboratory, the hobbies and interests of the students who belong to the laboratory are the research subjects, and we are studying methods so that the methods used in the research can be applied to other fields.

For example, one of the members is interested in sleep. He has unstable sleep, and some of his family have sleep disorders. Therefore, he is studying a method for visualizing the state of sleep. Nowadays, with the development and widespread use of smartphones and wearable measuring instruments, it is easy and familiar to know what is happening during sleep.

However, the internal measurement logic of these devices is unclear, and the ability to export data is not substantial. Therefore, we are developing a simple device that solves these problems. Due to the high correlation between sleep and health, this device allows device users to observe their health status on a daily basis.

Another laboratory member's hobby is fishing, and he has a lot of knowledge about fish. Therefore, we apply his knowledge of fish to the discrimination of fish species. The methods used in this study are machine learning and signal processing, and take advantage of these two methods. The method we propose can be expected to be applied not only to discriminate the type of fish, but also to discriminate male and female and class of fish, inspect agricultural products, and inspect machine parts.

2. Device that keeps track of your sleep status

2.1 Sleep and health

It is well known that there is a high correlation between sleep and health. For example, Sleep Apnea Syndrome (SAS) is a disease in which breathing stops during sleep, and it has been reported that about 80% of people with SAS also have lifestyle-related diseases [1]. Since there is no concept of complete cure for lifestyle-related diseases, the preliminary group of SAS and early detection may be able to detect lifestyle-related diseases at the pre-illness stage.

Paediatric orthostatic dysregulation (OD), which has been attracting attention in recent years, is also a disease of the autonomic nervous system that is highly correlated with sleep. OD is more likely to occur during puberty, and the estimated number of affected people is said to be about 700 thousand [2]. The characteristics of OD disease are that you cannot get up in the morning, have a headache, and somehow feel tired, which leads to factors such as school refusal and social incompatibility later. Therefore, as with SAS, early detection and treatment are required for OD, but because there are few OD specialists, patients with OD often cannot receive treatment from specialists at the right time and at the right frequency (2).

Similarly, hypotension (HT) in the elderly is also highly correlated with sleep. Today, with increasing health consciousness, hypertension and its treatment are attracting attention, but it is said that one in three elderly Japanese people suffers from HT. The problem with this disease is a fall due to fainting, and there are concerns about secondary accidents such as bruising and injuries such as fractures during the fall. Talking to people with HT, it seems that their sleep condition has been poor for several days before the onset of symptoms [3].

2.2 **Breathing depth and health**

Similar to the correlation between sleep a health, the depth of breathing is also highly correlated with health. For example, when the autonomic nerves are disturbed, breathing becomes shallow during sleep as well as during awakening.

The authors believe that if it is possible to grasp the state of sleep by counting the number of breaths during sleep, it is possible to predict disease changes not only in patients with SAS but also in patients with OD and elderly HT. In other words, the shallower the breathing during sleep, the higher the number of breaths. If such a condition is observed, it is possible to predict that the symptoms of the disease will be more likely to appear.

2.3 **Analysis by breath sounds during sleep**

Currently, patients are required to visit at least three times for a simple test and a main test until they are diagnosed with SAS at a medical institution and start treatment. The simple test is performed at the examinee's home using a device rented from the medical facility, and the main test is performed at the medical facility in an overnight hospitalization called a polygraph test. In these tests, the examinee must wear a SAS-specific measuring device on his body. Wearing the device and sleeping outside the home are stressful for the examinee, and it is difficult to get normal sleep.

Considering the above problems, the author has conducted early detection of SAS and discrimination of the preliminary group based on the breath sounds during sleep [4]. The IC recorder is a non-contact device and has the advantage that it does not cause physical and mental stress on the subject and allows the subject to sleep as usual. Therefore, if a simple diagnosis using this is put into practical use, it may be possible to simplify the hospital visit before the start of treatment.

However, SAS diagnosis based on sleep apnea sounds has the problem of being highly dependent on recording conditions. For example, in cases where there is a bedroom along a busy road, a resident next door has a TV on all night, or it was raining at the time of recording, the breath sounds during sleep are canceled by these noise sounds. I can't measure it.

2.4 **Understanding sleep with a wearable device**

With the spread of wearable measuring instruments in recent years, daily health and sleep measurement using smartphones has become widespread. However, wearable devices must be worn on the body and can interfere with sleep. In addition, there is no function to export data, and little has been announced how to measure sleep status with a wearable measuring device. This problem is the same when measuring sleep status using the smartphone app. Clarification of measurement method and data export are indispensable.

2.5 **Device development**

From the background up to the previous chapter, the authors have begun to develop a device for counting the number of breaths during sleep, which is a reasonable and data-utilizable, non-contact type with a dedicated antenna attached to a small high-frequency analyzer.

Similar to the correlation between sleep and health, the depth of breathing is also highly correlated with health. For example, when the autonomic nerves are disturbed, breathing becomes shallow during sleep as well as during awakening. The shallower the breathing during sleep, the higher the number of breaths. In this way, if it is possible to grasp the state of sleep by counting the number of breaths during sleep, it is possible to predict disease changes not only in SAS-affected persons but also in OD and elderly HT-affected persons. The main features of this device are as follows.

1) Dedicated non-contact simple device

Measurement with this device is non-contact with the body.

2) Data can be exported

Since the data can be exported, medical staff can utilize the data.

3) Clarify the analysis method

In the application created by the authors, the analysis method is specified. Also, since the data is open, the method is left to the analyst.

4) Can be measured repeatedly on a daily basis

Because it is reasonable and simple, daily measurement is possible repeatedly.

5) Expected report that the symptoms of the disease appear prominently

In patients with OD and elderly HT, the worsening of the disease state is that the respiratory rate during sleep is shallower or more disturbed than usual. Since this device can continuously measure and analyze sleep states, it is possible to anticipate and report the tendency of these symptoms to worsen.

Currently, we are designing this device while sending a signal from a function generator to a high-frequency analyzer and checking the state of its waveform with an oscilloscope.

3. Support for the primary sector of industry by AI and signal processing

3.1 Problems of primary industry in Japan

Fish is the staple food of the Japanese people, and Japanese fresh fish and fish dishes are highly evaluated worldwide. In the ocean of Yamagata prefecture where our KOSEN is located, it is one of the most diverse fishing areas in Japan. With the declining birthrate and aging population, "improvement of working style" is being promoted in Japan. The fishing industry, which is the first industry, also needs this improvement, and the aging of manual workers, the shortage of workers and the shortage of successors are still problems.

3.2 Support for the fishing industry

One of our lab members has a hobby of fishing and he wants to support the fishing industry, where our KOSEN is located and his hometown. Our KOSEN is located in Yamagata prefecture in the Tohoku region of Japan, and is known for its wide variety of landed fish. So he focused on the selection of fresh fish at the fish market. At the landing site near our KOSEN, the elderly are sorting the types of fresh fish landed almost alone. At work sites, old women often select fresh fish piled up on concrete by themselves. Since they work in the middle waist, their legs and lower back hurt. In order to reduce such labor, we would like to discriminate the type of fish by image processing that combines deep learning and signal processing technology. We would like to propose methods and techniques that take advantage of these two advantages. In the Japanese industry, where the birthrate is declining and the population is aging, we are aiming for coexistence with automation utilizing humans and AI.

We visited the landing site of fresh fish and interviewed the workers. Then, I summarized their specific problems and countermeasures for them. Fish that have been sorted by fishing boats arrive at the landing site for fresh fish. Therefore, a high-priority and necessary item for them is the selection of the size and type of specific fresh fish at the landing site of fresh fish. Therefore, we are testing the feature extraction of these fresh fish images using the two-dimensional continuous wavelet transform (2DCWT). In the future, I would like to combine 2DCWT with machine learning, especially among AI, to take advantage of these methods.

4. Conclusions

In this paper, we have described the research subjects of our laboratory and the background and outline of choosing the subjects. Currently, we have just begun basic research on these issues, and there are many problems, and we are repeating trials. We would like to continue these studies in the future and explore further issues. And we want to apply our challenges to other areas.

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IMPLEMENTATION METHODS AND PEDAGOGICAL EFFECTIVENESS OF STUDENT-DRIVEN ONLINE SCIENTIFIC EVENTS

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Abstract

To continue STEM education for children and to educate students, this study is implementing an interactive online experiments and crafts classes that can be implemented in the COVID-19 pandemic, and accumulating practical know-how. We have conducted more than 10 student-driven online experiments and crafts classes for children since June 2020, found benefits and problems, and made improvements based on questionnaire surveys. The surveys have shown that this activity also improves the students' generic skills. In particular, students themselves feel that their communication, problem-solving, and explanation skills have improved more than in face-to-face activities, and the interactive online experiments and crafts classes provide an excellent opportunity to improve these skills. In addition, the interactive online experiments and crafts classes are a useful educational method even in the post-COVID-19 era, as they enable continuous STEM education that is not affected by social conditions such as infectious diseases or the children's environment (mountainous areas, remote islands, pediatric hospital wards, out-of-school, overseas, etc.).

Keywords: *STEM, Online, Experiment and Craft Class, Generic Skill, Post COVID-19, PBL*

Introduction

In recent years, experiments and crafts classes for children have been held in various regions as a form of science communication and ongoing STEM education. However, due to the COVID-19 pandemic starting in 2020, many face-to-face science events were cancelled. Furthermore, although science events have been conducted in an on-demand format, with experiments and craft videos provided online, few interactive online science events have been conducted, and interactive science communication has drastically decreased. In our school, student-driven experiments and crafts classes for children had served as a place for student education as well as STEM education for children, but as mentioned above, the science event was cancelled or postponed.

We have been implementing an interactive online experiments and crafts classes in cooperation with students since June 2020 to continue STEM education for children and to educate our students. We have established implementation methods and found benefits and problems through more than 10 implementations by June 2022. A detailed study of the educational effects on children and student staff is an issue for the future, but the questionnaire survey has also revealed that the activities can improve the generic skills of the students.

This paper presents a detailed implementation of interactive online experiments and crafts classes that can be conducted even in the era of the COVID-19 pandemic, and discusses the potential of online experiments and crafts classes in the post-COVID-19 era based on survey results.

Purpose and Significance of Science Events

There are three main purposes of science events for children. The first is the main purpose of the event, which is to convey the joy of science to children, to arouse their interest in science, and to help them acquire a scientific background regardless of their career path.

The second is to raise the science background of the community as a whole by getting not only children, but also their parents and other adults, interested in science. This will lead to an increase in the number of children choosing science-related career paths, and we can expect an increase in the number of applicants to our school.

The third is the educational effect on students. By conducting student-driven science events, not only are children educated, but also students can expect to gain a deeper understanding of science and improve their generic skills, such as communication, problem solving, and explanation.

Implementing science events with these three purposes will enhance the significance of science events, not only as an education for children, but also as a method of community revitalization and education for students.

Status of Scientific Events prior to COVID-19

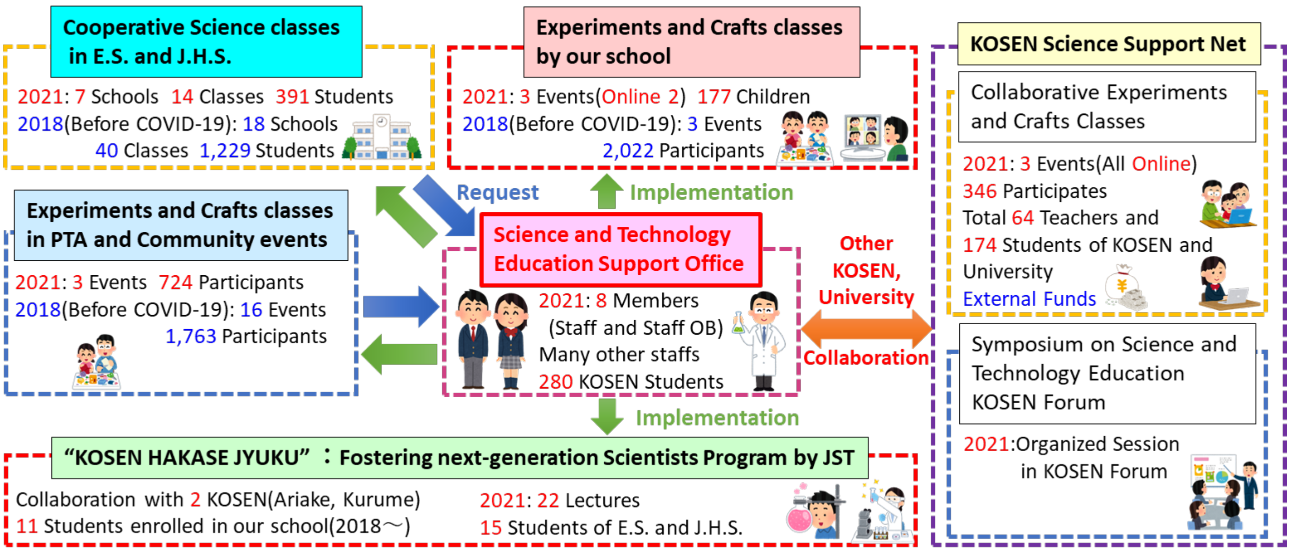

Fig. 1. Science events in our school

Prior to COVID-19, our school had about 50 science events per year. All events, including cooperative science classes at elementary and junior high schools, exhibits at PTA and community events, science events hosted by our school, and joint science events of the KOSEN Science Support Net, were conducted face-to-face. As much as possible, we conduct these events in a student-driven manner (Fig. 1).

In cooperative science classes with elementary and junior high schools, our teachers mainly conduct classes that further develop the content learned during science class at elementary and junior high schools in the Yatsushiro area. In junior high school, all 18 schools take turns for a year, and popular activities include experiments using liquid nitrogen, observation of radiation using cloud chamber, experiments on earthquakes, and observation of cell division. At elementary schools, the program is offered only to schools that request it, but about 10 schools per year. Popular topics include experiments on electricity and magnetism, and talks on weather and typhoons. Students and children seem to take an even greater interest in science when they receive classes that develop what they have learned at school (Fig. 2).

Fig. 2. Cooperative Science classes with elementary and junior high schools

The PTA and community events have requested about 15 requests per year to conduct experiments and crafts classes and to exhibit at events. These requests are made to club activities on campus, and as much as possible, the planning and operation of these events is student-driven. Communicating with people in the community provides a good opportunity for students to develop their communication skills.

Our school hosts about three science events per year, two small, one-lecture type events and one large, school-wide science event. The large science event has grown in participants over the years, and in 2019 had over 2,000 participants in a day. Students, faculty, and staff worked together to prepare more than 20 exhibit courses for this event, and outside organizations were invited to exhibit and enjoy a full day of science at our school (Fig. 3).

Fig. 3. Large Science event in 2019

In addition, KOSEN Science Support Net, a group of people in charge of science education support at National Institute of Technology(NIT) in the Kyushu-Okinawa area, also held science events. By collaborating in the management of classes, we were able to communicate

with people from other colleges and companies, and the activities were highly effective in terms of students' education.

On the other hand, we have also implemented the "KOSEN HAKASE JYUKU" project, funded by JST, in collaboration with NIT, Ariake College and Kurume College, for the purpose of fostering next-generation human resources who excel in science, mathematics, and information science.

Changing Status in the COVID-19 Pandemic and Towards the Implementation of Scientific Events

As mentioned above, our school has been actively conducting student-driven face-to-face science events, but due to the COVID-19 pandemic, face-to-face events were cancelled or postponed beginning in February 2020. The school also became an online school, and both faculty and students were busy for some time preparing for online classes, assignments, etc. However, in order to continue science education for children and to continuously foster the generic skills of our students, we began to consider interactive online science events as a new form of science event around May 2020. We encouraged student members of the club that had been conducting experiments and crafts classes to take the initiative in planning this student-driven event. After extracting themes that were suitable for an online event from those that had been conducted in face-to-face activities, they chose a theme related to "sound". As for crafts, they decided to make a flute using straws. Since the students were unable to attend school and were in the online class, we held many meetings using Microsoft teams and Zoom, and conducted an interactive online experiments and crafts class in June 2020, combining experiments and crafts. The class was then conducted twice with the same theme to brush up the content and improve the skills of the students who taught it.

The above class is a theme-learning type class with only one theme, but we used this class approach to plan a large scale, diverse- experience type science event. In other words, we aimed to bring online a large-scale experiments and crafts classes with more than 20 classes that had been conducted at face-to-face sessions prior to COVID-19. Students, faculty, and staff collaborated, and with the help of the KOSEN Science Support Net and other outside parties, the event was held in November 2020. Although the event did not attract as many participants as face-to-face, it was well appreciated by the participants and demonstrated its potential as a new form of large-scale science event in the COVID-19 pandemic. Subsequently, KOSEN Science Support Net hosted two events by March 2021 and one theme-learning type event and three large scale diverse-experience type science events from April 2021 through March 2022. Details of the implementation methods and implementation status are described below.

Methods for Implementing Online Scientific Events

In the online implementation, we aimed to conduct the event on-time, not on-demand. This was because we wanted to communicate with the children in real time while conducting experiments and crafts, and wanted both parties to enjoy the science event in the same way as if it were conducted in face-to-face situations. In addition, since there are many on-demand experiments and crafts classes available on YouTube and other sites, our goal was to realize a face-to-face science event online. Therefore, we decided to conduct an interactive science event.

As the event was online, we recruited participants via flyers and our website, and had them register in advance. We prepared kits with materials divided into small portions for each person, and sent them to participants with their Zoom IDs and passcodes. Student staff also held online meetings in advance and practiced with Zoom when face-to-face meetings were not possible. In addition, since many participants had concerns about the network connection according to the results of the questionnaire described below, a connection test was conducted in advance.

The choice of theme and the method of implementation on the day of the event depended on the format of the interactive science event. In the theme-learning type class, the event was conducted in such a way that all participants learned about one theme through lectures and experiments and made crafts at the end of the class. The contents of the lectures and experiments were also discussed by the students-driven group, and on the day of the event, the lectures and demonstrations were given simultaneously to the participants using Zoom. After the lecture, crafts related to the theme were conducted, and when there were many participants, the participants were divided into groups and guided in the crafts using the breakout room function of Zoom. the theme that has been conducted since 2020 is about "Sound", and the craft was making Straw Pan flute.

On the other hand, in the diverse-experience type science event, we prepared about 20 classes, with each class taking about 40 minutes to conduct, in order to replicate a large-scale face-to-face science event online. We set up four time slots as shown in Table 1, and asked the participants to select the class they would attend in each time slot when they made their registration. In addition, an opening session was prepared before the class and an ending session was prepared after the class so that participants and staff could participate and feel a sense of togetherness of the event even in the online class. In particular, the ending featured experiments with a giant air cannon, a water rocket, and liquid nitrogen, which participants enjoyed as much online as in face-to-face sessions. On the day of the event, the implementation system was as shown in Fig. 4. The headquarters was set up at the Yatsushiro campus of our school, and the students and faculty teaching the class participated online from the Yatsushiro campus or from

their homes, while the children participated online from their homes. In addition, a Zoom meeting was held always at the headquarters to handle any problems as well as openings and endings. The method of implementation in each class was left to each group, and they practiced and implemented the class in advance, using breakout rooms and other resources to make the class easier to teach.

Table 1. Schedule for the day of the event

9:30 ~ 9:35	Opening
10:00 ~	Lecture 1
11:00 ~	Lecture 2
12:20 ~12:40	Lunch Meeting for Staff
13:00 ~	Lecture 3
14:00 ~	Lecture 4
15:00 ~15:20	Ending

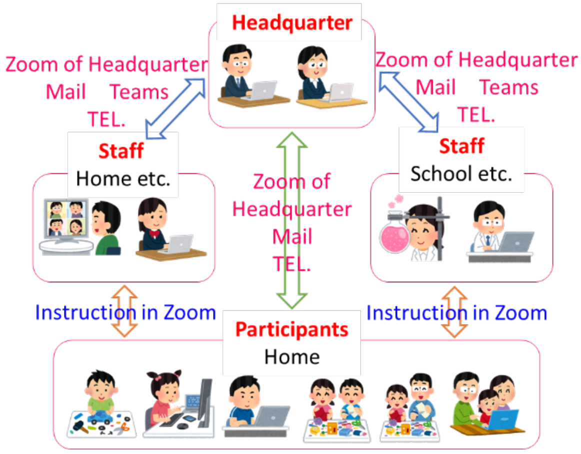

Fig. 4. Implementation system

Status of Online Scientific Events in the COVID-19 Pandemic

By the end of June 2022, we had conducted 11 interactive online experiments and crafts classes (Table 2). Theme-learning type experiments and crafts class was the starting point of this activity, and 4 events were conducted by students in club activities. When students were not able to attend school, teachers conducted only the demonstration experiments at the school, but the content and scenarios of the lectures and experiments were created by the students, and the teaching methods of the crafts were devised and implemented by each group taught in the breakout room. As the number of times the event was held, the results of participant questionnaire surveys improved, and the students were confident in their instruction.

On the other hand, the diverse-experience type experiments and crafts classes were conducted for the purpose of reproducing the large-scale face-to-face science events online as well. Online events with a maximum of 22 classes were also conducted, and a total of 7 events were held with other KOSEN, universities, and outside parties exhibiting online (Fig. 5, Fig. 6). However, the science event in May 2022 was conducted in face-to-face, since the infection status had calmed down, and only some classes were taught online from off-campus to the participants who came to the school.

In addition, we improved the diverse experiential classes based on the questionnaire results, and we also conducted network connection tests in advance, demonstration experiments of the endings, Zoom

Fig. 5. Student staff conducting online classes

Table 2. Status of online scientific events in the COVID-19 pandemic

Type	Date	Theme	Participants	Student Staffs
Theme-Learning	2020.6.28	Lecture and Craft about Sound	15(7 groups)	Club members:11
	2020.7.19	Lecture and Craft about Sound	8(6 groups)	Club members:8
	2020.8.23	Lecture and Craft about Sound	16(11 groups)	Club members:9
	2021.6.26	Lecture and Craft about Sound	16(10 groups)	Club members:10
Diverse-Experiences	2020.11.7	Spring Telephone etc. Total 18	98(63 groups)	6 KOSEN students:69
	2021.1.17	Slim etc. Total 9	27(20 groups)	6 KOSEN students:40
	2021.3.14	Kaleidoscope etc. Total 10	51(40 groups)	5 KOSEN students:37
	2021.9.5	Electrostatic Jellyfish etc. Total 22	99(65 groups)	6 KOSEN and 1 University students:77
	2021.12.19	Drinking Bird etc. Total 16	84(50 groups)	7 KOSEN and 1 University students:48
	2022.3.6	Spinning Magnet etc. Total 15	163(110 groups)	5 KOSEN and 1 University students:44
	2022.5.21	Straw Pan flute etc. Total 27 (25 Face-to-Face and 2 Online)	167(102 groups)	3 KOSEN and 1 University students:100

Fig. 6. Participants taking an online class at home

meetings of the headquarters, and online lunch meetings among the staff members.

Questionnaire

In order to improve the event and to clarify problems with the online scientific event, we conducted questionnaire surveys of the participants and student staff. The surveys were conducted using Microsoft forms, and the responses were received from about 65% of the participants and 60% of the student staffs. Useful questions are listed and analyzed below.

First, analyses of the questionnaires to the participants will be conducted. "Did you enjoy the event?" "After the event, were you more interested in science and crafts?" "Would you like to take the class again?" The positive responses to these questions were almost 100%, indicating a high level of satisfaction among the participants. "(Q.1) Was the overall explanation easy to understand?" (Fig. 7) was generally favorable, but there were some differences depending on the theme, but we have not yet conducted analysis by theme, which is an issue to be addressed in the future. As for "(Q.2) Grade of participants" (Fig. 8), the distribution did not differ much from that of the face-to-face sessions.

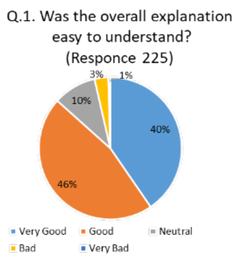

Fig. 7. (Q.1)

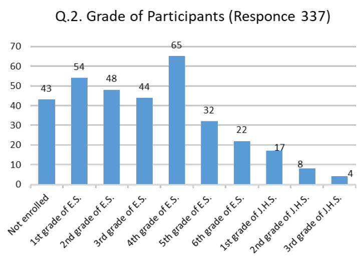

Fig. 8. (Q.2)

"(Q.3) Compared to face-to-face implementation, did you have any concerns before the event?" (Fig. 9) and "(Q.4) After the event, were those concerns resolved?" (Fig. 10), the respondents seemed to have had more than a few concerns, but most of them seemed to have been dispelled after the event. "(Q.5) Would you like to participate in similar events in the future?" (Figure 11), more respondents said they would like to participate if it is online, compared to questionnaires for other face-to-face classes. Thus, it was found that there is demand for online experiments and crafts classes in post-COVID-19, and that this is an implementation method that should be continued in the future.

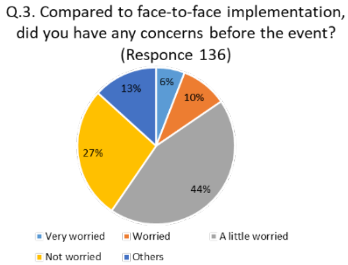

Fig. 9. (Q.3)

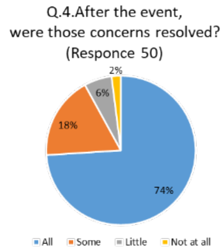

Fig. 10. (Q.4)

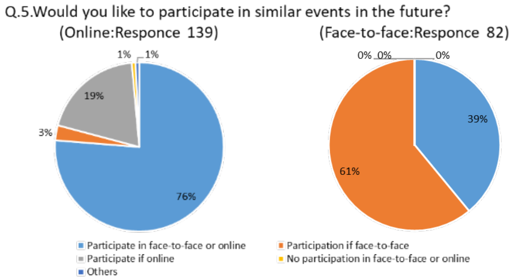

Fig. 11. (Q.5)

The following is an analysis of the questionnaire for the student staff. Regarding "(Q.6) How were you feeling before the event?" (Fig. 12), some students seemed concerned because of the online event. "(Q.7) Did you have good communication among the student staff in preparing for the event?" (Fig. 13), "(Q.8) Were there any problems on the day of the event?" (Fig. 14), "(Q.9) Did you have good communication among student staff during the implementation of the event?" (Fig. 15), it seems that to some extent communication was good among the students and they were able to handle any problems on the day of the event. However, communication was not as good as in face-to-face meetings, and online exchange meetings in advance of the event are necessary. Regarding "(Q.10) Did you

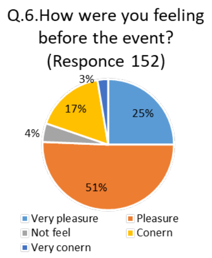

Fig. 12. (Q.6)

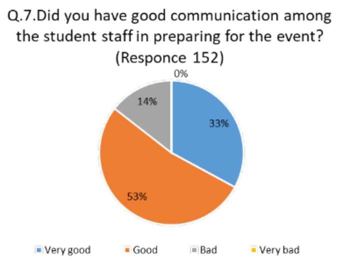

Fig. 13. (Q.7)

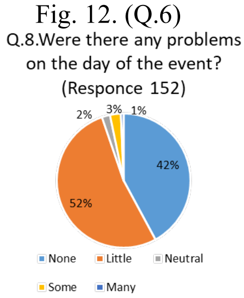

Fig. 14. (Q.8)

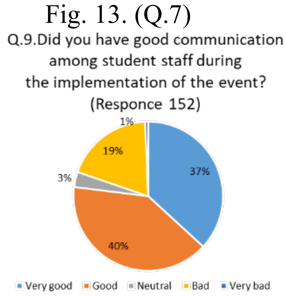

Fig. 15. (Q.9)

enjoy the event you attended?" (Fig. 16), most students seemed to enjoy the event itself. Regarding "(Q.11) Would you like to participate in similar events as a staff member in the future?" (Fig. 17), the majority of students indicated that they would like to participate; however, there were some students who would not try again if the event did not go well. The number of students who said they would participate if it were face-to-face and the number of students who said they would participate if it were online were about equal, indicating that there is demand for online experiments and crafts classes even in the Post COVID-19 era, according to the participation of student staff.

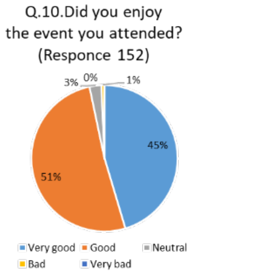

Fig. 16. (Q.10)

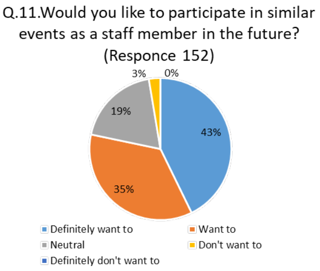

Fig. 17. (Q.11)

Conclusions

Based on the results of the above questionnaire and the responses to the free-response questions, points for improvement were clarified, and the event has been implemented while making repeated improvements. The network and devices that were a source of concern for participants and student staff were resolved to a certain extent through connection tests conducted in advance. Another factor, online communication between participants and student staff, as well as between students in the same class, can be sufficiently resolved through careful discussions among student staff, practice of lectures, and the effective use of information equipment.

In addition, although it is more difficult to manage a class than a face-to-face class, it is possible to conduct a class with the above mentioned careful meetings and study of the explanation method. Furthermore, since the PDCA cycle from preparation to implementation and improvement must be successfully executed, it is highly effective in educating student staff and leads to the development of generic skills such as logical thinking, creativity, communication, and teamwork skills more effectively than face-to-face lectures. Detailed surveys will be conducted in the future.

On the other hand, there are many requests for face-to-face implementation, but as the survey results show, there is also demand for online implementation in post COVID-19, so we will continue to implement the event and accumulate implementation know-how. Furthermore, the event can be implemented not only for children in remote areas, but also for children who are not attending school or who are hospitalized for a long period of time. In order to foster English communication among student staff, online classes for children overseas are also expected.

Acknowledgements

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THE USE OF IMMERSIVE TECHNOLOGY TO ENHANCE STUDENTS' HANDS-ON LEARNING EXPERIENCE IN ELECTRONICS PRACTICAL LESSON

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Abstract

Virtual and Augmented Reality (VAR) technology is slowly gaining interest and is being used as a medium in technical education. The immersive and interactive nature of this technology makes it more suitable for experiential learning. In this paper, we are reporting the use of this immersive technology to enhance students' hands-on learning experience in Electronics practical lesson for a foundation subject in engineering which is offered to a very large cohort of more than 1000+ freshmen. Learning challenges are often encountered by many of the students as they do not have any prior knowledge or hands-on experience in Electronics, not to mention a wide spectrum of learning abilities. During the practical lesson, the facilitator introduces the instruments and demonstrates the circuit patching and procedures to read various circuit parameters and complete the experiment. As the instruments and procedures are new to students, not all students will be able to follow the instructions and complete the measurement of various parameters. VAR technology enabled learning resources help the students in understanding the procedures at their own pace and complete the experiment without the need for the facilitator to repeat the procedures. It also helps the highly motivated students to go through the resources at their free time and come well prepared for the practical sessions and check with the facilitator on the application of the concepts discussed during the practical session. On the other hand, it also frees up the facilitators time, so they can focus on the weak students who need help with the circuit patching and measurements. VAR technology enabled learning resources are well received by the students. The students welcome the use of immersive technology which is very engaging and in turn helps them to learn better and retain the knowledge. Based on the findings, we conclude that immersive technology is a promising tool for enhancing students' learning for the practical sessions of engineering modules.

Keywords: *immersive technology, virtual reality, augmented reality, 360-degree virtual reality, immersive learning.*

Introduction

Polytechnic education in Singapore emphasizes strongly on practice-based learning. Students interested in pursuing a more practice-oriented pathway may apply for diploma courses at the polytechnics. Education statistics digest (2021) reports that around 48 percentage of students from post-secondary education are enrolling into polytechnic of which around 4800 students enroll to engineering courses. Circuit Analysis is the core electronics module offered to the freshmen in their first semester of the polytechnic diploma study in the School of Engineering. This module is offered through flipped approach where the students attend tutorials and pratical lessons in small groups. A pilot run on flipped classroom for two fundamental engineering subjects for diploma course is reported by (Abelanes & Pratima, 2015). These flipped classroom implementations reported active learning environment, increased student engagement and more interaction time between students and the facilitator. While flipped classroom has proven its effectiveness in tutorial lessons, little has been explored to enhance the learning experience of hands-on practical lessons for these subjects. Laurillard et al., (2013) points out that effective teaching modes, appropriate teaching tools, and the arrangement of teaching activities are the essential elements of a successful learning process which is applicable even for the practical lessons. Traditionally, technology creates learning opportunities for students to explore disciplines through authentic methodologies and removes information barriers that often limit the content and experiences that the students encounter. Siegle, D. (2019) reports that, with virtual and augmented reality apps, students can actively interact with content in new ways. They immerse themselves into environments in which they are not physically present, but they feel like they are experiencing the environments. Virtual Reality (VR), Augmented Reality (AR), 360-degree virtual reality are actively being incorporated into education, teaching, and training in various engineering applications reported by Martin, S. et al., (2020), Mehmet, M. & Yasin, O. (2012), Radianti, J., et al., (2020), Björn, S., et al., (2020), Xu, X., & Wang, F. (2022).

In traditional practical lesson, the facilitator explains the objective of the lesson and introduces the components and instruments needed for the particular experiment.

Facilitator also shows the experimental setup and explains the procedure to measure or observe the readings of certain parameters in the experimental setup. As students have very short attention span, apart from the verbal explanation and demonstration, to enhance the hands-on learning, students need to have other resources like the immersive learning resources, that help them to interact with the spatial space, relate the content to the practical experimental set up and learn at their own pace. Lab sheets are the handouts given to students at the beginning of the semester which has the details of the experiment, components and instruments needed, the experimental setup, the procedure to complete the experiment and get it validated by the facilitator. To introduce elements of immersive technology, QR codes that link up to the experimental set-up or animated demonstrations are inserted at appropriate sections inside the lab sheets. Siegle, D. (2015) points out that these codes make learning with technology easier for students and motivationally engage them in the 3D space. Felder, R. M., & Silverman, L. K. (1988) divide learners into five major groups based on their learning preferences. Figure 1 shows the suitability of the VAR learning resources to learners with different learning styles.

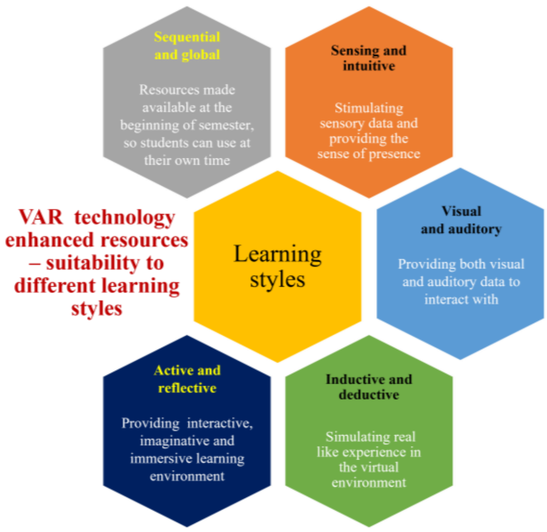

Figure 1: Learning styles

In this paper, we discuss the use of the VAR based resources for facilitating the practical sessions that helps the students to learn better, retain and apply the knowledge; development of the learning resources; feedback and impact of the resources on students' performance and conclusion.

Subject Delivery

A flipped learning approach was used in a first year first semester engineering subject called Circuit Analysis. Students were enrolled for this subject in a 15-week semester. This subject gives an introduction of DC and AC circuits, and theorems and laws that are useful in the analysis of the circuits. Students were split into small groups of 25 students in each group. Apart from the weekly four-hour tutorial session, as there is a strong emphasis on practice-based learning, students were scheduled for a weekly two-hour practical lesson as well. Students were expected to do a pre-reading of the lab sheets given to them and come prepared for the practical lesson. During the practical lesson, with the guidance given by the lab facilitator, students will follow the instructions in the lab sheets and complete the lab procedures. Students will also be able to relate the lab findings to the theories that they learned during the tutorials. The practical lesson plan is designed with appropriate teaching activities and is delivered using the suitable teaching tools that facilitate student learning. Based on students' feedback, from time to time, the teaching activities and the application of the teaching tools are reviewed to suit the learning needs of the students. Very large classes need careful planning and organization to avoid confusion and falling into chaos. A considerable amount of time is needed to plan the teaching activities so that the students will benefit through this approach.

360-degree Virtual Reality

Circuit Analysis, which is one of the core modules, is offered to freshmen where majority of them are post-secondary students with no hands-on experience in electronics. Electronics lab setup, electronic components like the breadboard and the electronic instruments are all new to the students. Apart from the guidance from the facilitator, appropriate learning resources will help the students in orienting themselves to the electronics lab setup and familiarizing themselves with the instruments to carry on with the experiments. As the recent pandemic hit at the beginning of the semester, the students didn't get an opportunity to visit the electronics lab. They were not aware of the electronics lab setup, the electronic components, and instruments. This pandemic driven situation triggered the development of the learning resources based on 360-degree virtual reality which exposes the students to real-time interactions within the virtual environment. In the 360-degree virtual reality, based on the camera angles captured by the device, the locations of viewers are fixed. Reyna, Jorge. (2018) reports that dragging the 360-degree images up, down, right, and left provides the students with an interactive experience, also offers a unique sense of presence and immersion which is not achieved with the other traditional methods.

Development of the 360-degree Virtual Reality Learning Resources

Before students could start doing the experiment, they need to be familiar with the electronic instruments for the experiment. For the experiment on AC circuits, students usually find the initial set-up of the instruments like the oscilloscope and function generator to be overwhelming.

Hence it was decided to develop 360-degree virtual reality learning resource to support the students in familiarizing with the two instruments. 360-degree images of the electronics lab and the workbench with the set of instruments were captured using the Insta360 Evo camera. 360-degree images were then imported into Unity software, which is a real-time AR, VR, 2D and 3D game development platform. Text, image, video or MCQ hotspots were then introduced, so the students could interact with the 360-degree images. After visual rendering and optimization, the game package was exported for Windows platform. Figure 2 shows the development cycle of the 360-degree VR learning resource.

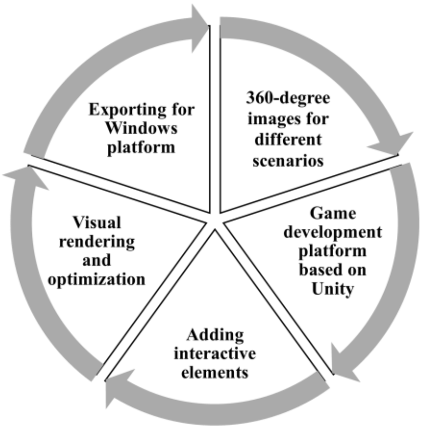

Figure 2: Development cycle

Figures 3 and 4 shows the 360-degree images of the electronics lab, and the workbench with the set of instruments.

Figure 3: 360-degree image of the electronic lab

Figure 4: 360-degree image of the workbench

To make the learning, immersive and real-like, three interactive scenarios were created using the Unity game development platform.

Scenario 1: Familiarization of the electronics lab

During covid-19 pandemic, students did not have access to the practical lab venues; hence they were unfamiliar with the electronics lab environment. To be more prepared for such situations in future, a scenario on familiarization of the electronics lab was introduced. 360-degree image of the electronics lab was imported into the Unity game development platform. Text and image hotspots were introduced so students could be familiar with the electronics lab environment, availability of the components and option to teleport to scenario 2. Figures 5, 6 and 7 shows the screenshots of scenario 1.

Figure 5: Welcome page

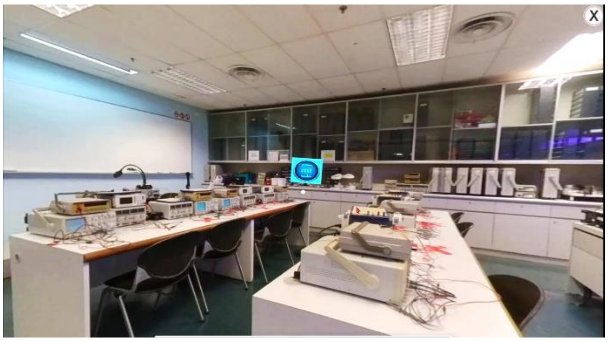

Figure 6: Scenario 1 – Text / image hotspot

Figure 7: Teleport to Scenario 2

Scenario 2: Oscilloscope

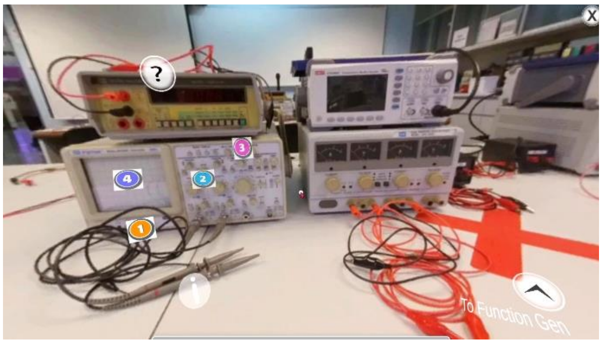

Figure 8: Scenario 2 – Video and MCQ hotspots

360-degree image of the workbench was imported into the Unity game development platform. Video hotspots to explain the usage of oscilloscope probes, and the procedural steps in the initial set-up of the oscilloscope were introduced. Multiple Choice Question (MCQ) hotspot to help students to check on their understanding of the experimental procedures were also added. Figure 8 shows the screenshot of scenario 2.

Scenario 3: Function Generator

Video and MCQ hotspots were included in this scenario too. Video hotspots explain the use of the function generator cables and procedural steps in using the function generator. Figure 9 shows the screenshot of scenario 3. Figure 10 shows a student learning from the 360-degree VR resource.

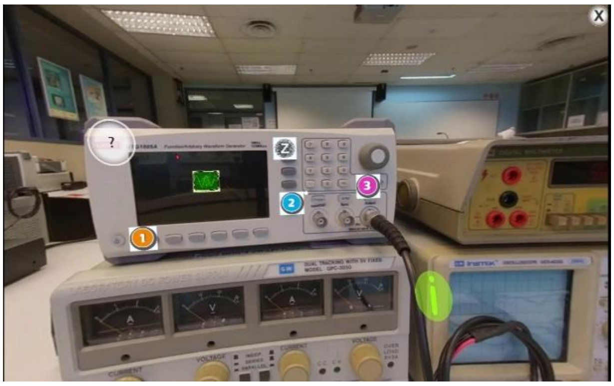

Figure 9: Scenario 3 – Video and MCQ hotspots

All the three scenarios were put together, and after visual optimization and rendering, the package was exported as a zip file to be used with the Windows platform. Downloadable link to the package was made available to students through the Learning Management System (LMS). Students were also given instructions on navigating around the game package and to teleport to different scenarios.

Figure 10: Student learning from 360-degree VR resource

Augmented Reality

AR technology tries to augment virtual information on the real environment for maximizing user interactivity and learning experience. Indeed, AR allows supporting learning, for example increasing-on content understanding and memory preservation, as well as on learning motivation. As the Electronics practical sessions are new to the students, they need more guidance in following the instructions from the lab sheets. Hence QR codes were used as visual marker that directs the students to the images of the actual experimental setup and or animated demonstration of the experimental procedure. Students scan the QR codes using their handphones. They interact with the information provided and learn at their own pace either before or during the lessons.

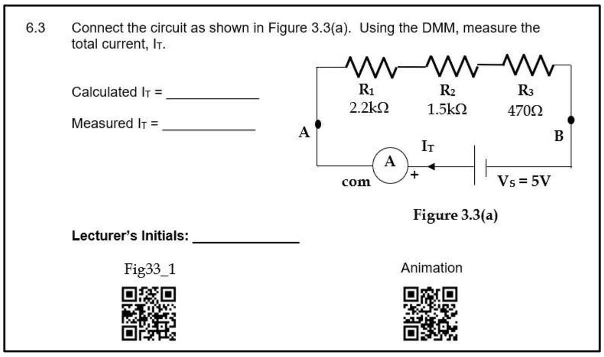

Figure 11: QR codes

Close to seventy QR codes of the actual experimental setup and or animated demonstration of the experimental procedure were inserted at appropriate sections of the lab sheets used throughout the semester. Figure 11 shows the QR codes added to the lab sheets and Figure 12 and 13 shows the augmented information that students interact with.

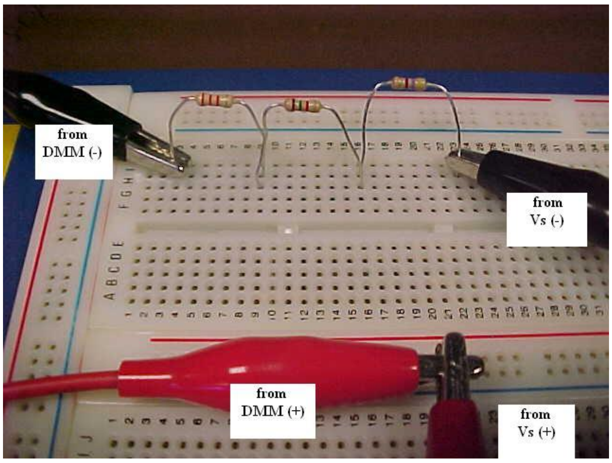

Figure 12: Actual experimental set-up

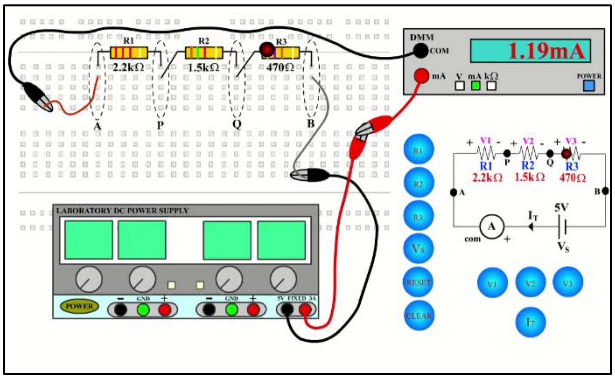

Figure 13: Screenshot of animated explanation of the circuit patch-up and experimental procedure.

Results and Discussion

VAR technology enabled resources were made available to the students from the April 2021 semester onwards and 1000+ students had access to these resources. Due to the immersive nature, students were motivated to use these resources for their learning. Students could use these resources to pre-read and come prepared for the practical lessons. It also served as a very useful resource for students to revise the lab procedures / familiarize with oscilloscope and function generator before the practical test. During the practical lesson, students were expected to complete the tasks as in the lab sheet and lab facilitator checks the students results and provides feedback. Lab participation marks (5% of the overall subject marks), was awarded to students based on:

1. Efforts: Manages time well; well prepared before lessons (read lab sheets, brings tools) and complies with all lab rules; willing to help others.
2. Skills: Demonstrate excellent lab skills; shows great confidence in using equipment.

The lab participation performance before and after the introduction of the VAR based learning resources was studied. The percentage of students with poor performance (F grade) during the practical lessons has dropped by almost half in the April 2021 as well as April 2022 semester. Apart from the guidance given by the lab facilitator, the augmented reality resources help the slow learners as well as high achievers to understand the lab experiment procedures and complete it at their own pace. It also promotes self-directed learning in the students.

Practical test is conducted at the end of the semester to assess the students' practical skills. A comparison of students' performance in the practical test over the past three years (April 2019, April 2021, and April 2022) was done. Due to pandemic, as students didn't have access to the physical lab for few weeks in the semester, practical test was not administered in April 2020 semester. After the introduction of the VAR based learning resources in April 2021 semester, there is a significant drop in the % of failures for the practical test to about half the failure rate as before. Students learn better, retain the knowledge gained and apply the knowledge during the practical test. Hence, there is also a 9% increase in the average marks for the practical test after the introduction of the learning resources in April 2021.

As part of subject review, a survey was done to collect feedback on subject delivery and students' performance. Questions on how students received the immersive technology resources was also added as part of the survey. Separate survey link but with the same questions was released to two groups of students.

Open Group: post-secondary students

Focused Group: students with other qualification

420 students from Open Group and 177 students from Focused Group responded to the survey.

Q1: The QR Codes in the lab sheet that are linked to the demo videos helped me in understanding the circuit patching and testing procedures.

Q2: 360-degree VR learning experience on oscilloscope and function generator was engaging and helped me in remembering the critical settings and tips for using the equipment.

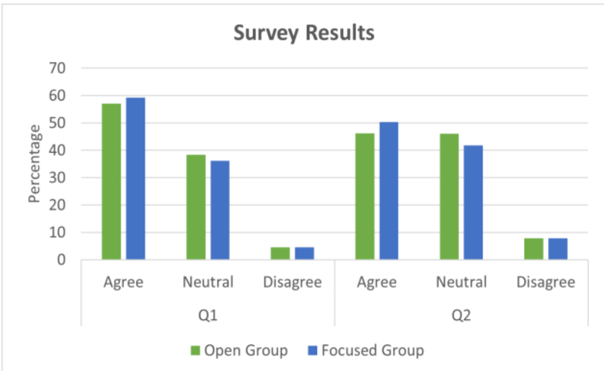

Figure 14: Survey results

Figure 14 shows the bar chart corresponding to the survey results. From the survey results, we understand that students found the QR code in the lab sheets to clarify the circuit patching and testing procedures. They also felt positive about the 360-degree VR learning resources to help them in remembering the initial setup of the equipment and steps in measuring the required parameters.

Conclusions

VAR technology enabled learning resources were developed and made available to very large cohort of students. Effectiveness of these resources in enhancing student learning were studied by analyzing feedback from students through student satisfaction survey. Due to the immersive nature of the resource, students were motivated to make use of them for their learning. More than 50% of the students agreed that the resources have helped them to understand the circuit patching and testing procedures, retain knowledge and apply them to do better during the practical lessons as well as the assessment. The drop in % of failures in the practical test and lab participation shows that the resources had helped the weaker students to learn better and in turn, do well for the assessments.

Implementation of the VAR technology enabled learning resources has resulted in notable benefits. 1. Promoting self-directed learning in students, due to the availability of the tool throughout the semester. 2. Efficient learning through immersion, interaction, and imagination. 3. Improving recalling the information for a longer period, 4. Providing an experiential learning tool that could facilitate transferring perceived knowledge into practice, 5. Collaborative learning and sharing during the practical lab lessons. 6. Suitability of the resources to learners with different learning styles.

To conclude, implementation of VAR technology enabled learning resources for a very large engineering subject was a success and had been effective in enhancing students learning, which is being measured from the students' performance in the assessments.

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EXPLORATION OF FACTORS AFFECTING COURSE OUTCOMES IN HOME-BASED LEARNING

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Abstract

Due to the COVID-19 outbreak, Republic Polytechnic (RP) activated Home-Based Learning (HBL) in the 2020 academic year. HBL practice requires the lesson designers and deliverers to respond quickly to get lessons ready for HBL. Therefore, it is important to investigate if students would have similar learning experience and achieve equivalent course outcomes as in Face-to-Face learning. This study aims to explore the factors affecting the course outcomes in HBL based on students' perceptions of HBL experience. Quantitative methods encompassing an 8-factor, 30-item survey were employed in this study. The survey items were adapted from instruments in the literature developed for assessing the course outcomes in e-learning/online learning and then customized to the RP's HBL context. A pilot study was conducted through factor and reliability analysis to verify, validate and refine the survey items. Survey responses were analysed through descriptive, comparative and correlational analyses. Survey findings were derived to summarize students' overall perceptions of HBL (descriptive), difference in perceptions of HBL across different semesters and different cohorts (comparative), and relationships between the various factors and their influences on the HBL course outcomes (correlational). The survey analysis and findings showed that, it is important to develop strategies to promote interactions between lecturers and students, to improve Social Presence element in HBL lessons, and to better understand students' challenges during HBL and help them overcome the challenges.

Keywords: Home-Based Learning, e-Learning, Course Outcome, Survey Design, Exploratory Factor Analysis.

Introduction

Due to the COVID-19 outbreak, Republic Polytechnic (RP) activated Home-Based Learning (HBL) in Academic Year (AY) 2020 Semester 1 for all full-time and part-time courses. Microsoft Teams (MS Teams) was employed by most courses to create a virtual learning environment (VLE) to deliver the lessons in a synchronous manner. The learning process was also supported by various other Information and Communications Technology (ICT) tools, such as Padlet, WhatsApp, Telegram, Google Doc, Learning Management System (LEO 2.0) Discussion Forum, MS Teams Chat and Class Notebook, etc.

As an institution which believes that knowledge and skills are constructed through social interaction, RP adopts learner centred approach, such as Problem Based Learning (PBL), to facilitating active, collaborative and reflective learning. In HBL, would students have similar learning experience and be able to achieve equivalent course outcomes as in Face-to-Face learning? To answer this question, it is important to examine what factors affect the course outcomes and how the factors contribute to the course outcomes in HBL.

The HBL implemented in RP can be considered as one type of e-learning/online learning supported by VLE. E-learning/online learning has been gaining more attention due to its flexibility, accessibility, cost effectiveness and variety of courses available. Thanks to the rise of Internet and new ICT tools, being physically present in a classroom isn't the only learning option anymore; e-learning/online learning has become a viable education alternative. According to a survey from Babson Survey Research Group[1], over 30 percent of higher education students in the United States are taking at least one e-learning course. Allen and Seaman (2008) indicated that online enrollments have been growing significantly faster than the higher education enrollments in general.

How effective is the e-learning/online learning? Numerous studies have been conducted on the course outcomes in e-learning/online learning and the factors affecting the outcomes. With course materials and learning activities mediated via ICT tools, it is important that learners have the knowledge, comfort, and confidence to leverage the technology for maximum benefit (Johnson et al 2008). The technology acceptance model (TAM) developed by Davis (1986) has been included in a number of studies on e-learning effectiveness. Two cognitive beliefs were posited in TAM: perceived usefulness and perceived ease of use. TAM has proven to be a theoretical model in helping to explain and predict user behavior of information technology (Legris, Ingham, & Collerette, 2003). Another important element in e-learning/online learning is interaction. Interaction allows individuals to share information, to receive feedback and to more readily evaluate progress (Piccoli et al., 2001). In Johnson et al (2008), interaction was defined as the exchange of information between the various stakeholders in the course: peers, instructors, and other support staff. Their study concluded that peer interaction was related to course performance and satisfaction. In addition, social

[1]https://www.educations.com/articles-and-advice/5-reasons-online-learning-is-future-of-education-17146

presence has been identified as key to the level of learner participation and success of online collaboration as well as satisfaction with online courses (Lakin, 2005). Research has shown that learners typically experience isolation and alienation in online learning environments, and one of the most common complaints by those participating in e-learning environments is a lack of a shared learning environment and connections with their peers (Moore, 2002). In light of this, Johnson et al (2008) specially addressed the importance of social presence and developed a model of e-learning effectiveness which adds social presence to other often studied variables. Wei et al (2012) presented a framework developed from the social cognitive theory for investigating social presence and its relationships with relevant factors. They also developed an instrument with sufficient reliability and validity to measure those factors. For a more comprehensive literature survey on the e-learning/online learning effectiveness, refer to Noesgaard and Ørngreen (2015).

Unlike e-learning/online learning, which is deliberately planned and carefully designed to provide alternative learning options for learners, the HBL in RP was the only option during the COVID-19 pandemics. The lesson designers and deliverers were required to respond quickly to get lessons ready for HBL. In this context, it is important to analyse the course outcomes and study the factors affecting the course outcomes in HBL. Fig. 1 below shows the factors explored in this study. In addition to the course outcomes and those factors commonly studied in the literature, Attitude (students' attitude towards HBL) and System Accessibility (how easily students can connect to the ICT tools during HBL) were also included in the study.

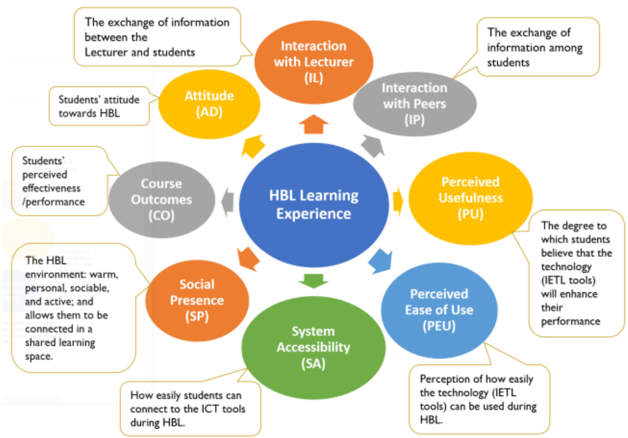

Fig. 1. Factors affecting HBL Learning Experience

The main research questions in this study are as follows:

1) What are the students' perceptions of HBL?
2) How do the perceptions of HBL differ across students from different semesters and different cohorts?
3) What are the relationships among the various factors and how do they influence the HBL course outcomes?

Methodology

A. Instrument and Data Collection

This study employed quantitative methods encompassing an 8-factor, 30-item survey. The items in the survey were adapted from instruments in the literature developed for assessing the course outcomes in e-learning/online learning and customized to the RP's HBL context. The survey items were scored on a five-point Likert-Scale, ranging from 1 (strongly disagree) to 5 (strongly agree).

The survey was administered online through Microsoft Forms towards the end of semester 1 and beginning of semester 2 in AY2020 to collect students' perceptions of HBL. Student volunteers were given the link to the survey and their informed consents to participate in the survey were obtained. Students were assured of anonymity during the research and in the subsequent publishing of the report, and all information was to be kept confidential. Ethics approval has been sought from the Polytechnic In-house Ethics Review Committee where the study was undertaken.

B. Selection of subjects and samples collected

Students enrolled in full-time diplomas in RP, semester 1 and 2 of AY2020 were invited to participate in the survey. The probability sampling method was used to collect data. The survey was administered randomly to full-time polytechnic students across various General, Discipline and Specialization courses covering year 1, year 2 and year 3 students. There were 436 and 630 responses collected in AY2020 Semester 1 and Semester 2, respectively.

C. The pilot and actual study

A pilot study was conducted based on the responses collected in AY2020 Semester 1. Exploratory factor analysis and reliability analysis were performed in the pilot study to validate and refine the survey items. With the refined survey items, responses were collected again in AY2020 Semester 2 to answer the research questions, draw conclusions and provide recommendations.

Results and Discussion

SPSS Statistics and SPSS Modeler were employed to perform the analyses.

A. The Factor and Reliability Analysis

Based on the 436 responses collected in AY2020 Semester 1, Exploratory Factor Analysis was first conducted to examine if the survey responses support the original survey design of eight factors. The Scree Plot (Fig. 2) identified six factors instead of eight based on eigenvalue > 1. The Pattern Matrix also showed cross loadings between some of the factors, indicating not strong enough bond between the items of certain factors. Reliability analysis was also performed to check the internal consistency among the items under each of the six factors identified. The Cronbach's alpha coefficient

achieved at least 0.7 for five of the factors except for System Accessibility where only two survey items were included in the factor.

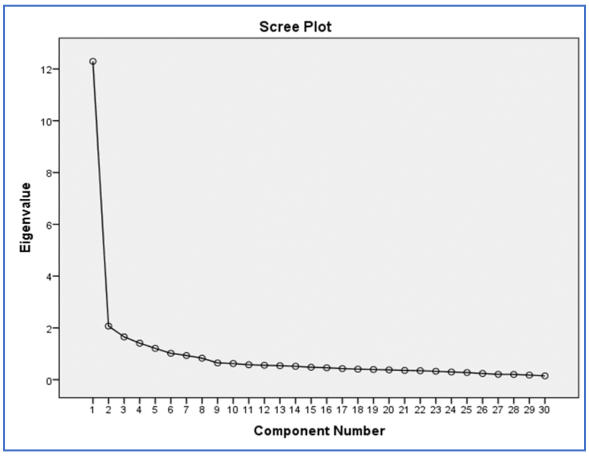

Fig. 2. Scree Plot for Data Collected in AY2020 Sem 1

Based on the analysis, survey items were closely examined and they were further refined through the following actions:

1) Relocate: some survey items were moved from one factor to another factor.
2) Rephrase: some survey items were rephrased to avoid ambiguity and misinterpretation by students.
3) Redesign: some survey items were discarded and redesigned to better support the factors.

After refinement, seven factors were kept in the revised survey questionnaire. For the removed factor (Attitude), the survey items were either merged into other relevant factors or removed due to repetitiveness.

Pattern Matrix[a]

	Factor						
	CO	PEU/PU	3	IL	IP	SP	7
CO5	.675						
CO3	.602						
CO1	.400			-.395			
PEU4		.719					
PEU3		.655					
PEU2		.521					
PU4		.490					
PU3		.368					
SP2			-.764				
CO2			-.611				
SA2			-.522				
IL2				-.765			
IL1				-.743			
IL3				-.738			
IL4				-.443			
IP1					.828		
IP2					.799		
IP4					.485		
IP3					.428		
SP3						.764	
SP4						.699	
CO4						.532	
SP1						.443	
IP5						.357	
PEU1							-.698
PU1							-.661
SA1							-.324

Extraction Method: Maximum Likelihood.
Rotation Method: Oblimin with Kaiser Normalization.
a. Rotation converged in 11 iterations.

Fig. 3. Pattern Matrix for Data in AY 2020 Sem 2

Based on the 630 responses collected in AY2020 Semester 2, Exploratory Factor Analysis was conducted again. In this case, the Scree Plot identified seven factors based on eigenvalue > 1. As shown in the Pattern Matrix (Fig. 3), the cross loadings between factors were negligible. Four factors were clearly identified (CO, IL, IP and SP). Three new factors emerged, one is to merge PEU and PU; one is for the three items under '3' which reflected more towards 'Ease in learning with ICT tools (EL)'; and the last one is for the three items under '7' meant for the 'Challenges faced during HBL (CF)'.

Reliability analysis was also carried out and the statistics were shown in Fig. 4. Cronbach's Alpha value > 0.7 for 6 factors except for 'Challenges Faced during HBL' which obtained a value of 0.668.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items	Sub-Scale
.839	.840	4	IL
.845	.845	4	IP
.848	.849	5	SP
.870	.872	3	CO
.852	.854	5	PU/PEU
.669	.668	3	CF
.788	.793	3	EL

Fig. 4. Reliability Statistics for Data in AY 2020 Sem 2

The analysis of the survey responses in Section B below was conducted based on the seven factors identified.

B. *Survey Result Analysis and Findings*

Descriptive - Students' Perceptions of HBL

To obtain students' perceptions of HBL and in turn understand their HBL learning experiences, mean score of the survey responses for each factor was summarized in Fig. 5. The highest mean score is 4 ('Agree' in the Likert Scale). The lowest mean score is below 3 (towards 'Disagree' in the Likert Scale). The three factors with the highest mean scores are: Interaction with Lecturers, PEU/PU and Ease in Learning. The two factors with the lowest mean scores are: Social Presence and Challenges faced during HBL. This shows, based on their HBL learning experiences, students' most satisfied and least satisfied factors.

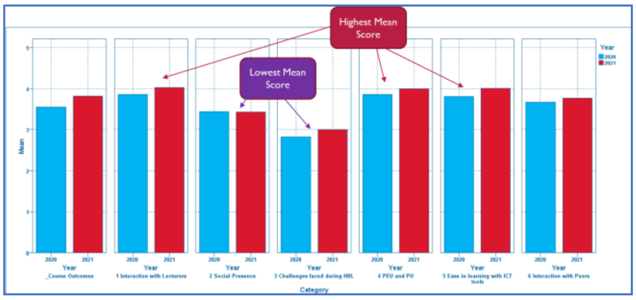

Fig. 5. Mean Scores of the Survey Responses

Comparative - How Students' Perceptions of HBL Differ across Different Semesters and Cohorts

Are there significant differences in students' perceptions of HBL across different semesters and across different cohorts? Comparative analyses were carried out to answer this question.

As the most important factor reflecting students' learning during HBL, perceived course outcomes across different academic semesters and different cohorts were first explored using Boxplot as shown in Fig. 6.

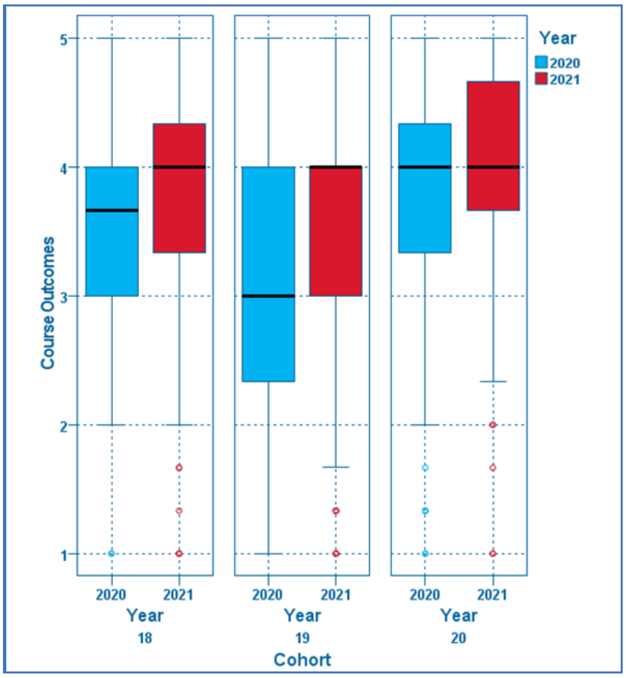

Fig. 6. Comparison of Perceived Course Outcomes

It is good to see that the perceived course outcomes improved for all cohorts from AY 2020 Semester 1 to Semester 2. The highest improvement was in Year 2 cohort. Among the three cohorts, Year 2 students had relatively low satisfaction of the course outcomes and Year 1 students had the highest level of satisfaction. Year 2 students experienced the most challenges during HBL perhaps because they were more used to the RP Face-to-Face learning and not yet independent enough as Year 3 students in their learning.

To understand the difference in each factor between different semesters, a comparison of the mean scores of the factors between AY2020 Sem 1 and Sem 2 was compiled in Fig. 7 below. The F-Test results showed that mean score of survey responses improved from Sem 1 to Sem 2 for all factors, except for Social Presence. As lecturers and students got more used to HBL learning environment and they became more familiar with the ICT tools employed in the learning, students' perceived learning experiences improved in semester 2.

Similarly, a comparison was conducted for the mean scores of the factors across the three different cohorts as shown in Fig. 8. There were significant differences among the mean scores of the factors across the three cohorts. In particular, Year 1 students were more satisfied with Interaction with Lecturers, Interaction with Peers, Social Presence and Course Outcomes compared with the other two cohorts. For Year 2 students, they were less satisfied with HBL in almost all factors except for Interaction with Peers (In this case, Year 3 students had the lowest mean score).

Grouping field: Year

*Cells contain: Mean, Standard Deviation, Standard Error, Count

Field	2020*	2021*	F-Test	df	Importance
_Course Outcomes	3.555 0.972 0.047 435	3.820 0.843 0.034 630	22.455	1, 1063	1.000 Important
1 Interaction with Lecturers	3.857 0.666 0.032 435	4.027 0.655 0.026 630	16.923	1, 1063	1.000 Important
2 Social Presence	3.438 0.784 0.038 435	3.434 0.775 0.031 630	0.006	1, 1063	0.064 Unimportant
3 Challenges faced during HBL	2.829 0.837 0.040 435	3.001 0.900 0.036 630	9.987	1, 1063	0.998 Important
4 PEU and PU	3.863 0.660 0.032 435	3.997 0.625 0.025 630	11.461	1, 1063	0.999 Important
5 Ease in learning with ICT tools	3.814 0.757 0.036 435	4.008 0.679 0.027 630	19.241	1, 1063	1.000 Important
6 Interaction with Peers	3.668 0.760 0.036 435	3.768 0.768 0.031 630	4.392	1, 1063	0.964 Important

Fig. 7. Comparison of Mean Scores across Semesters

Grouping field: Cohort

*Cells contain: Mean, Standard Deviation, Standard Error, Count

Field	18*	19*	20*	F-Test	df	Importance
_Course Outcomes	3.685 0.971 0.080 146	3.488 0.942 0.048 387	3.882 0.826 0.036 532	21.950	2, 1062	1.000 Important
1 Interaction with Lecturers	3.899 0.782 0.065 146	3.901 0.686 0.035 387	4.015 0.608 0.026 532	3.942	2, 1062	0.980 Important
2 Social Presence	3.386 0.841 0.070 146	3.306 0.772 0.039 387	3.544 0.751 0.033 532	11.020	2, 1062	1.000 Important
3 Challenges faced during HBL	3.059 0.938 0.078 146	2.795 0.788 0.040 387	2.994 0.912 0.040 532	7.706	2, 1062	1.000 Important
4 PEU and PU	4.005 0.709 0.059 146	3.830 0.634 0.032 387	4.006 0.619 0.027 532	9.357	2, 1062	1.000 Important
5 Ease in learning with ICT tools	3.986 0.775 0.064 146	3.817 0.744 0.038 387	3.995 0.673 0.029 532	7.551	2, 1062	0.999 Important
6 Interaction with Peers	3.478 0.956 0.079 146	3.619 0.726 0.037 387	3.875 0.703 0.030 532	22.403	2, 1062	1.000 Important

Fig. 8. Comparison of Mean Scores across Cohorts

Correlational – The Relationship among the Various Factors and their Influences on the HBL Course Outcomes

The first question answered by the correlational analysis was: what were the important factors contributing

significantly to the students' perceived course outcomes? As shown in the Predictor Importance plot (Fig. 9), Interaction with Lecturers is the most important factor, followed by Social Presence, Challenges Faced During HBL, etc.

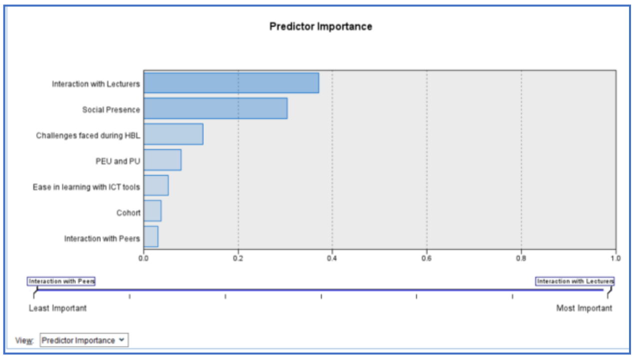

Fig. 9. Predictor Importance Plot

After identifying Interaction with Lecturers and Social Presence as the top two factors having strong correlations with the course outcomes, the second question answered by the correlational analysis was how each important factor contributed to the students' perceived course outcomes. Fig. 10 showed the regression analysis done for the correlation between Interaction with Lecturers and Course Outcomes. A positive correlation was observed with coefficient of determination R-square = 0.46. Similarly, Fig. 11 showed the regression analysis done for the correlation between Social Presence and Course Outcomes. Again, a positive correlation was observed with coefficient of determination R-square = 0.53. In both cases, the correlation coefficient r was about 0.7, indicating the correlation between course outcomes and these two factors to be moderate.

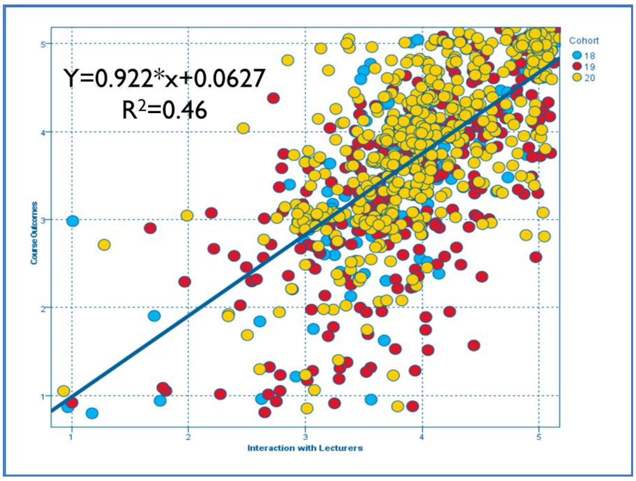

Fig. 10. Correlation between Interaction with Lecturers and Course Outcomes

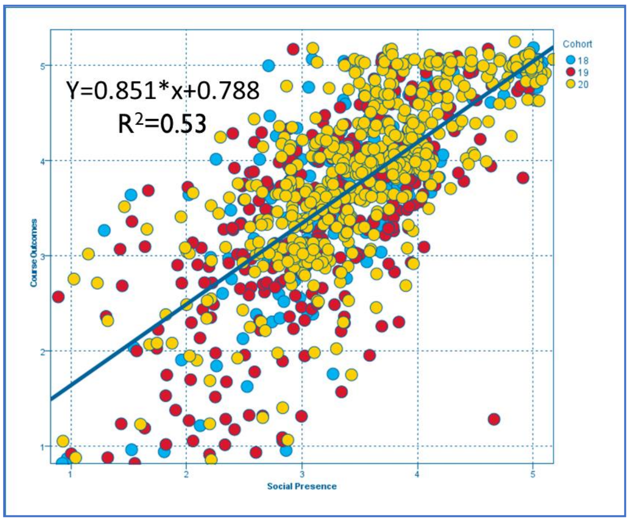

Fig. 11. Correlation between Social Presence and Course Outcomes

Lastly, the correlational analysis also explored how each pair of the factors related to each other through a correlation matrix as shown in Fig. 12. Those highlighted in dark blue indicated relatively high correlations. Social Presence (SP) was highly corelated with Course Outcomes (CO); it was also highly correlated with Interaction with Peers (IP). Obviously, high level of interaction between peers (IP) improved level of social presence (SP), and both factors contributed to satisfactory course outcomes (CO). The ease of use and usefulness of ICT tools (PEU and PU) were highly correlated with ease in learning during HBL (EL). The challenges faced during HBL (CF) was not strongly correlated with any of the other factors perhaps because only particular students faced challenges from time to time which was not representative of the HBL experiences of most students.

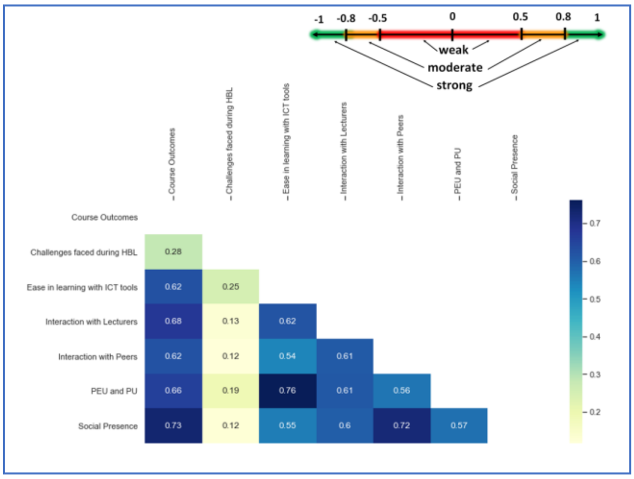

Fig. 12. Correlation between any Two Factors

C. Implications, Limitations and Future Research

Here are some insights gained from the analysis and findings discussed above.

1) The Interaction with Lecturers was the most significant factor contributing to Course Outcomes, and meanwhile it was the most satisfactory factor based on the survey responses. This indicates that lecturers in RP did an excellent job in terms of interacting with their students when supporting students' learning during HBL. It also revealed that it is recommendable to design more activities to promote interaction between lecturers and students in HBL lessons.
2) Social Presence was the 2nd important factor contributing to Course Outcomes, but it was also the factor with the lowest level of satisfaction based on the survey responses. This indicates that the current lesson design and delivery needed further improvement to take into account the Social Presence element in HBL lesson design.
3) Year 2 students seemed to face the most challenges during HBL. More attention and efforts should be spent on Year 2 students to better understand their challenges and to take actions in lesson design and delivery to help them overcome the challenges.

This study has a few limitations as discussed below. First, the study was conducted purely through quantitative methods. Mixed methods study which involves quantitative as well as qualitative data collected through interview or focus group discussions would help triangulate data and enhance validity of the findings. Second, the course outcomes were evaluated through students' perceived learning and satisfaction gathered through survey. It might be more objective to include students' academic assessment results as additional measures of course outcomes. Third, the correlation analysis only showed how each factor contributed to the course outcomes and how each pair of the factors correlated to each other. In future research, we may include qualitative data and academic assessment results to improve the analysis. Moreover, Confirmatory Factor Analysis and Structural Equation Model might be employed to further confirm the relationships among the factors and simultaneously examine the interrelated dependencies among the factors and their contribution to the course outcomes.

Conclusion

In this paper, we studied the factors affecting the course outcomes in HBL for RP students during the COVID-19 outbreak. A survey adapted from instruments in the literature and customized to the RP's HBL context was used to collect students' perceptions of HBL experience. Factor and reliability analysis were conducted in the pilot study to verify, validate and refine the survey items. Survey responses were analysed and survey findings were derived to summarize students' overall perceptions of HBL (descriptive), difference in perceptions of HBL across different semesters and different cohorts (comparative), and relationships between the various factors and their influences on the HBL course outcomes (correlational). The insights gained from this study would be valuable to the management, lesson designers and deliverers when they develop strategies to better meet students' learning needs during HBL, such as promoting interactions between lecturers and students, improving social presence during HBL, and helping students overcome the challenges faced during HBL.

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INTEGRATING PEER-TO-PEER INTERACTIONS TO IMPROVE STUDENTS' PROBLEM-SOLVING SKILLS

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Abstract

Engaging students to develop problem solving skills through peer-to-peer learning is not a new discussion. Peer instruction is a 'specific evidence-based instructional strategy' widely used in science related modules across many universities (Tullis & Goldstone, 2020, p.1). Here, peer instruction is adapted to the context of peer-to- peer learning where students are provided with a facilitated environment to share and discuss their project ideas with peers. Students are introduced to the teaching and learning strategy of peer-to-peer learning through small group sharing with peers (e.g. each member will take turns to share their planning to the group they are allocated to). The objective of this strategy is to encourage students to understand the project topic in group discussions and not rely on more competent peers to take ownership of the project.

This paper focuses on learning about the effectiveness of peer-to-peer learning on developing students' problem- solving skills. To determine this, a mixed methods methodology focusing on post module students' survey, lecturers' observations and reflections and students' academic performance, were used to triangulate the data. 93 students enrolled in the Diploma of Child Psychology and Early Education (CPEE) Capstone Project module provided their feedback on the use of peer-to-peer learning and its effectiveness on learning. The survey feedback, coupled with students' academic performance highlighted the benefits of students' ability to see their project topic from another perspective and provided a sense of direction for their project development. Students also commented that their communication skills improved and there was an increase in confidence to share their ideas. Academic performance of students also saw a jump in one grade when compared with the previous run of the module. From the lecturers' observations and reflection, there was a perceivable increase in constructive questions during consultations and students were more motivated to participate in their projects by problem solving instead of seeking solutions from the lecturer. Overall, students took more ownership of their project development and they were more proactive in problem-solving issues arising in their project. Recommendations are included for educators who are interested to adopt a peer-to-peer learning approach in their module.

Keywords: *Peer-to-peer learning, project development, problem solving skills, educators' facilitation, teaching and learning strategies*

Introduction

Peer instruction is not a new teaching strategy used in universities to develop students' learning experiences in the area of physics (Tullis & Goldstone, 2020[i]). Peer instruction was developed by Professor Eric Mazur who discovered the benefits of peer instruction in students' learning and understanding in his own classroom (Mazur, 1997 [ii]). Peer instruction is perceived as a student collaborative approach towards students' development of problem-solving skills, critical thinking and decision-making skills (Cortright, Collins & Dicarlo, 2005 [iii] ; Lasry, Mazur & Watkins, 2008[iv]).

Compared to traditional methods of teaching, peer instruction invites students to participate in the process of using peer discussion as a means for students to discuss a question which the student had attempted individually. The process of discussion allows students to discuss their answers, resulting in some students sharing their perspectives or making alterations to their answers. In this context, students engage in social interaction through the exchange of explanations and understanding (Brooks & Koretsky, 2010[v]). Meaningful learning occurs as the increase in student participation and learning in or through discussions help students to close the gaps in their understanding and application, developing students' ability to apply their knowledge to problems (Giuliodori, Lujan, & DiCarlo, 2006[vi]). Cortright, Collins and Dicarlo (2005) identified the necessity to prepare students for the real world by providing opportunities to appropriate and apply what they have learnt into different situations. Peer instruction develops in students the ability to "interpret, relate and incorporate new information with existing

knowledge and apply the new information to solve novel problems" (ibid, p.107).
Lasry, Mazur and Watkins (2008) reported in their study of peer instruction from Harvard University to two-year college concluded that peer instruction contributed more to students' conceptual understanding compared to a traditional lecture method. Students with either high or low background knowledge benefitted from peer instruction.

What is peer-to-peer learning?

In context, peer-to-peer learning adapts from peer instruction by developing an environment for students to share their group's perspectives with a group of peers in relation to a specific topic/question. Similar to the design of peer instruction, peer-to-peer learning attempts to provide students with opportunities to apply a concept learned, then communicate their group perspectives through explanations and gather constructive feedback from their peers. These opportunities to apply students' conceptual learning occurs only in the tutorial setting. Boud (2013[vii]) defined peer learning as "not a single, undifferentiated educational strategy" the notion is abstract and involves "a two-way reciprocal learning activity" (p.3). Peer-to-peer learning benefits students mutually though the sharing of feedback and ideas with each other (Boud, 2013). Students develop learning as they explain their ideas with each other and reflect on the feedback received. The evaluation process aids students in the ability to organize, plan, communicate and evaluate their learning.

Contextual Framework

The peer-to-peer learning is introduced as a holistic learning approach in the module, Capstone Project at Ngee Ann Polytechnic (NP), Singapore. A total of 102 Year 3 students were enrolled in Capstone Project as part of the requirements for the Diploma in Child Psychology and Early Education. Students enrolled in this module need to select a focus topic and form groups of 4-5 with students of similar interest. As part of the conversion of Capstone Project to a non-implemented project during the Covid pandemic, students will need to work with early childhood centres instead of selecting from a wider pool of family services, non-profit organisations, community clubs and other community related organizations. Students will also not be implementing the proposed projects.

Based on the collective past experiences as a lecturer to this module, students tend to lack confidence and would refer to the lecturer for reassurance instead of attempting to address the issue/problem. Given the Covid pandemic climate, there was a need to adopt a teaching strategy that would scaffold students towards gaining confidence to apply their domain knowledge to plan activities to address real life issues. To facilitate students' learning in an adapted pandemic setting, peer-to-peer learning was introduced to increase students' ability to problem solve more independently.

Students were introduced to the peer-to-peer strategy at the beginning of the module. The aim of this strategy was to allow students to understand how peer-to-peer learning could be adopted to facilitate students' learning. Figure 1 illustrates the teaching and learning strategies used in the various stages of students' learning. As students took on the role of a teacher facilitator, they would need to have a good grasp of the different strategies used and how to gain 'buy-in' by the students to ensure a quality learning experience.

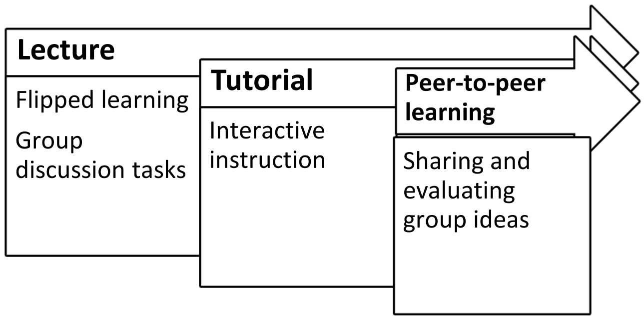

Figure 1: Module T&L Design

Lecture Design

Lectures were conducted in a "Flipped learning" design via online asynchronous learning. Direct instructions related to the module content were presented, so that students could gain knowledge related to project development concepts. A K-W-L template was introduced in the lecture, to help students document their learning. The K-W-L template aided in student's independent learning and reflection. This process provided the grounding to facilitate group discussions and peer-to-peer learning during face-to-face tutorials. Checkpoints were provided in the lecture content so that students were able to pause and think how the knowledge gained could be appropriated to their project individually. Students were also given the opportunities to work together at the end of the lecture, to consolidate the knowledge to their project development.

Tutorial Design

Tutorial design was conducted virtually using MS Teams as the main platform. Breakout rooms were used for group discussions. Breakout rooms provided students with the space to work as a group. Tutorial design consisted of the following elements (1) recap of lecture concepts (2) application of concepts via guided questions (3) one member of the group will be assigned to another group to share their plan (see Figure 2).

Students were provided with an interaction instruction where a summary of their lecture concepts and questions were posted for students to work as a group. In this process, students were able to discuss their views on the questions and its relation to their project

development. These ideas were later shared with students of another group. Each student would be allocated a number and students with the same number would form a group to share their plans in the breakout room. This process aimed to allow students to develop a greater sense of ownership of their projects.

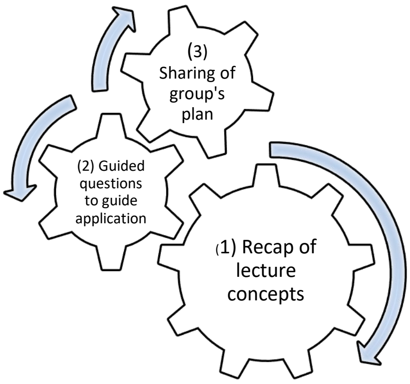

Figure 2: Tutorial design

Peer-to-peer learning and the role of the educator

Peer-to-peer learning was set up as the focal point of every face-to-face tutorial. Students would engage in their project group discussions before they were given an assigned number so that students were able to share their discussion plans with students from other groups. In other words, there should be one member from each group in one group discussion. After each peer sharing, students would provide their comments and feedback in terms of the feasibility of the group's ideas in relation to the project topic.

The educator was the facilitator of the peer-to-peer learning. As facilitator, the intent was to enable students to make better connections to their thinking skills and explain their perspectives through their comments and feedback during the peer-to-peer learning. Instead of viewing the educator as the 'giver of knowledge', students perceived the peer-to-peer learning as a platform of collaborative learning.

Results

The action research focused on integrating peer-to-peer learning to improve students' problem-solving skills.
102 students who enrolled in the Diploma of Child Psychology and Early Education (CPEE) Capstone Project module provided their feedback on the use of peer-to-peer learning and its effectiveness on learning. The students were third year full time students, engaging in an early childhood related issue that they have identified during their diploma. The students attempted the survey at the end of the module course. The response rate was 93 of 102 students.

Survey Outcomes

The effectiveness of peer-to-peer learning on students' problem-solving skills were evaluated and triangulated using

- students' reflections,
- post module survey,
- lecturer's observations and
- academic performance

Students' reflections

Students highlighted the benefits and comments of K-W-L template and the peer-to-peer learning in the areas of helping them in their thought process and developing communication, listening and accepting constructive feedback. These areas helped student to increase their confidence in problem solving simple issues as the K-W-L template aided students to critically evaluate on the problems encounter and the consider constructive feedback provided by peers and lecturers.

(a) K-W-L Template

Students mentioned that the K-W-L template provided the structure in the learning of concepts, organizing the project and applying the concepts in their project development. The K-W-L templated helped students to question, process, reflect and apply the concepts learned in the lectures and how they can organize their learning to achieve more realistic goals for their projects. The K-W-L template scaffolded students' learning and prepare students to apply the lecture concepts to the peer-to-peer interactions. Students commented that it took time to appropriate the template and understand how the template can aid as a tool to their learning and reflection of concepts. Nonetheless, the benefits of the K-W-L template aided in keeping learning on the 'right track', resulting to higher confidence to solve simple problems.

(b) Peer-to-peer learning

The peer-to-peer learning was highlighted as an opportunity to develop an open-mind towards receiving and accepting different views with respect. Students recognized that the constructive feedback in developing a more aligned project especially when the perspectives shared were not on the right track. Students highlighted that they developed confidence in the process as they communicated the group's plans and listened to the feedback provided by their peers. Some students indicated that they had to step out of their comfort zone to share their group's ideas. These opportunities contributed to the development of communication and listening skills.

Overall, peer-to-peer learning provided opportunities for students to document their learning and questions. Peer-to-peer learning also helped the students to develop their confidence, communication and listening

skills. Overall, these three attributes (being open minded, acceptance of different views and increased confidence) mentioned by students reflected they were more willing to question and attempt to apply their problem-solving skills.

Post module survey

Students were invited to participate in a post-module survey consisting of Likert scales (1= Strongly disagree and 5= Strongly agree) and open-ended questions. 72 of 102 students responded to the survey and provided their feedback. The post-module survey focused on gathering students' feedback using two main sections – (a) Providing feedback on the tools used in their learning (b) Lecturer's facilitation. The objectives of the post-module survey highlighted if students' experiences through peer-to-peer learning helped students to problem solve issues encountered in their projects.

(a) Providing feedback on the tools used in their learning

68.1% of the students rated peer-to-peer learning (peer dialogue and peer evaluation) as Very effective and Effective. Based on the quantitative data collected, students elaborated that the benefits of peer-to-peer learning towards their learning experiences helped students to do the following:

- Improve project ideas through clarifications
- Clarify their doubts about their project topic through sharing sessions. This helped students to better understand the topic better.
- Keep their project in check – they are moving in the right direction
- Test the feasibility of the project activity plans

On the other hand, students also highlighted limitations of peer-to-peer learning as the effectiveness of this tool was largely dependent on the amount of constructive feedback provided by peers. Introverted students felt uncomfortable during the peer-to-peer learning as they were not familiar with the other students. These introverted students indicated that peer-to-peer learning added stress and did not help in their learning. Lastly, students also highlighted the need for students to see the value of peer-to-peer learning to support their learning experiences. Otherwise, the value of peer-to-peer learning is lost.

From the open-ended questions, students further elaborated how peer-to-peer learning contributed to the overall development of the module. Students indicated that peer-to-peer learning benefitted the students' learning in the following:

- Helped me to take into consideration another person's perspective (63 responses)
- Improved communication skills (48 responses)
- Increased confidence to share ideas (48 responses)
- Taught me to be flexible and more adaptable (46 responses)
- Helped me to apply my EC knowledge (36 responses)

45.8% of students indicated that they would recommend peer sharing dialogues and peer evaluations to other modules. 37.5% of students indicated 'Maybe'.

(b) Lecturer's Observations

Throughout the module, the lecturer reflected on every face-to-face tutorial and the use of peer-to-peer learning. The following are the lecturer's reflections:

- Students were more confident in engaging in basic problem-solving skills. Instead of approaching the lecturer for a solution, students engaged in group discussion to attempt to find a solution to the issue.
- Students were more critical in the different perspectives suggested by peers during peer-to-peer learning. The students attempted to question and justify their plans to peers. This has led students to engage in basic problem-solving skills during their peer-to-peer discussions.
- Students engaged in more self-learning and reflection during the independent study. The direct instruction lecture concepts and peer-to-peer learning helped students to see the importance of their application of learned lecture concepts in their project planning. This largely occurred during each group's completed group pre-tutorial tasks assigned.
- Students displayed more self-motivation to learn as they were more aware of the learning goals of each tutorial discussion. This has resulted to increased participation as students look towards peer-to-peer learning as the means to present and evaluate their project plans.
- Consultations were more constructive as students asked higher-order questions instead of 'how to' questions related to issues. This

displayed students' willingness to engage in problem-solving skills more independently

Academic performance

The student's academic performance of the Capstone Project module resulted in a positive variance of 3.85 compared to the last run of 0 variance (no change in students' performance). A positive variance meant that students displayed an improved overall result. Students scored a high B grade compared to the last run of a low B grade, highlighting that peer-to-peer learning contributed to an overall improvement of the students' performance.

Students were able to score a grade higher (average B) in the Literature Review assignment compared to the previous run of a low C+ grade. The group component saw an average of one grade better from B to B+. Class participation and e-Reflection also saw a higher grade of B compared to the previous run of a low B grade.

Better academic performance could be attributed to the opportunities for groups to engage in peer-to-peer learning through more scaffolded opportunities to apply their learned lecture concepts. Peer-to-peer learning opportunities helped students to develop more ownership and increased participation towards their project. This resulted to increased students' problem-solving involvement and engagement in project issues.

Discussion

Peer-to-peer learning (comprises of peer sharing dialogues and peer evaluations) when designed carefully has benefitted students' learning through deliberate use of scaffolded activities in students' learning process. Students can see the value of the peer-to-peer learning in their learning and project development process. As a result, there was an increase in student engagement and participation as students were more aware of their project development process. Direct instructions indicated in the flipped learning lecture slides and the K-W-L template, helped students to reflect more about the appropriateness of the content to their project development. These two elements set the foreground for students to apply their learned concepts through project group discussions and peer-to-peer learning discussions.

Students were more confident in the project development process and they were more willing to engage in problem solving as a group. This is evident in how students demonstrated their motivation in overcoming their projects issues and the level of participation in asking more constructive questions leading up to project consultative sessions. Hanson, Trolian, Paulsen and Pascarella (2016) indicated that peer learning constitutes benefits related to students' learning outcomes. Chan (2012) [viii]further elaborates that students learn how to communicate with others, deepened learning through discussions and construct new knowledge on their own when they are provided with an environment where peer learning can occur.

Areas of improvement

However, there are areas of considerations when attempting to engage peer-to-peer learning with students.

K-W-L Template

K-W-L template was introduced as a tool to help students in their reflection and learning process throughout the module. Most students could see the value of the K-W-L template as a refresher tool towards the application of methods introduced; a small group only saw the template as a task and did not see the link in benefitting their learning.

There was a need to make deliberate reference to the K-W-L template so that students were prompted to use the template as a learning tool to facilitate their learning in the module. This could be carried out during consultations and group discussions.

List of starter questions

As students may not be familiar with the design of peer-to-peer learning, a list of starter questions could be provided to guide students in what to consider and look out for in their peer-to-peer learning with others. The list of starter questions would provide a structure to conversations and feedback. This would help students to focus on the objectives of the peer sharing dialogues and evaluations and help introverted students in their sharing.

Differentiated students' learning

Peer-to-peer learning (Peer sharing dialogues and evaluations) may not be strategies that all students were comfortable with. Introverted students may require more scaffolding questions, to facilitate the sharing of perspectives. These scaffolding questions would act like a structure for introverted students to learn how to present and communicate their perspectives to peers.

Lecturer's role

The role of the lecturer is flipped from a giver of knowledge to a facilitator of peer-to-peer learning in the classroom. This is an important feature of peer-to-peer learning so that lecturers can focus on supporting students in their discussion (if required), Taking a deliberate step back compared to the traditional mode of teaching is critical to the success of peer-to-peer learning. Students would benefit

from the space provided as a result the opportunity to present and evaluate perspectives. In other words, lecturers need to play a proactive role in the facilitation of peer-to-peer learning. Lecturers need to intentionally design objectives and activities that provide students with the opportunities to engage in peer learning (Hanson, Trolian, Paulsen & Pascarella, 2016)[ix]. Hanson, Trolian, Paulsen and Pascarella (2016)[x] identify this relationship as 'shared responsibilities' between students and lecturers (p.192).

Conclusion

Peer-to-peer learning as a learning tool has helped students to develop critical thinking, problem-solving and communication skills in this module. Even though some students indicated limitations of peer-to-peer learning due to their introverted personalities, students still reap the benefits of improved confidence and taking ownership of their project development. The step to explore the role of the lecturer as a facilitator, is not an easy one. However, the benefits outweigh the challenges as the lecturer's planning helped students to venture into this new way of learning. Lecturers need to step out of their comfort zone of direct instruction and take on the role as a facilitator. The role of the facilitator is reinforced by the activities designed that purpose to create an environment of peer-to-peer learning.

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A practice of deep learning by Knot Theory and DNA

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Abstract

We propose teaching materials concerning DNA recombination using knot theory. As a field of topology, knot theory allows the mathematical study of knots of loops. Since a knot is easily understood visually and there is little prior knowledge required for understanding it, a knot is suitable as a learning material for wide generations. Moreover, it can be applied for studying the shape of DNA and protein and many other fields of science. In the age of Society 5.0, which is a concept of a future society advocated by the Japanese government, human resources with the skills to grasp things from multiple perspectives and solve problems, known as STEAM (Science, Technology, Engineering, Art, and Mathematics) human resources, are required.

We have practiced STEAM education in the "Liberal Arts Special Lecture" for the 4th year students of the main course (1st year of the undergraduate course) since 2019. Teachers of general liberal arts subjects present themes by making use of their own specialties such as mathematics, debate, and economics. Through collaborative learning between students from various departments, we have led them to deep learning as fusion of knowledge and creation so far. However, there are few opportunities to give back to the society, especially a place to provide the acquired mathematics ability. Therefore, we created STEAM teaching materials on knots and DNA for extension courses for junior high school students and practiced early STEAM education for such students by utilizing the abilities of liberal arts special course students as teaching assistants.

We created learning material from a study of knots and DNA and practiced it with junior high school students last October. In the learning material, the shape of DNA is regarded as a knot and DNA recombination is considered mathematically. As a result, the students and the teaching assistants highly rated the materials and felt they had a good opportunity to give back to society by making use of their acquired ability.

Keywords: *Mathematics education, STEAM education, Topology, Knot Theory, DNA recombination*

§1. Introduction

Introduced by G. Yakman, STEAM education is the notion an approach to learning that uses science, technology, engineering, the arts, and mathematics as access points for guiding student inquiry, dialogue, and critical thinking to solve problems in the real world.

The main purpose of this work is to create STEAM teaching materials on knots and DNA for extension courses for junior high school students and practice early STEAM education by utilizing the abilities of liberal arts special course students as teaching assistants.

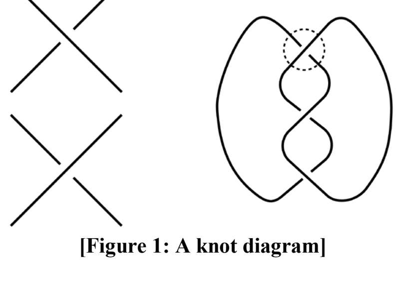
In section 2, we explain knots and DNA. The tricolorability of a knot is introduced in section 3. In section 4, we describe the structure of an open course. The content of our practice is outlined in section 5. We review the scenes of open course with some photos in section 6. Section 7 includes a description of the results of the questionnaire obtained from the participants. Finally, concluding remarks and future challenges are provided in section 8.

§2. Knots and DNA

First, we define a knot and a knot diagram and provide some examples.

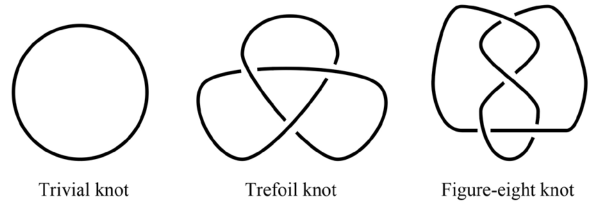
Definition 2.1. A *knot* is (an embedding of) a circle in 3-dimensional Euclidean space.

Definition 2.2. We consider the projection of a knot onto a plane. By small changes of a knot, we may assume that the projection is one-to-one except at a finite number of double points, known as *crossings*. The projection that is distinguished between the over- and under-strand at each crossing is referred to as a *knot diagram* (Figure 1).



[Figure 1: A knot diagram]

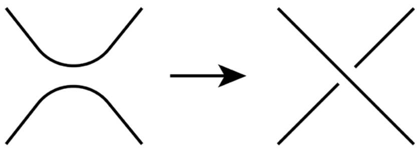
Example 2.3. Knot diagrams illustrated in Figure 2 are called a *trivial knot*, a *trefoil knot*, and a *figure-eight knot*, respectively.



[Figure 2: Examples of knots]

DNA is a polymer composed of two polynucleotide chains that coil around each other to form a double helix. Chromosome DNA, plasmids, and viral DNA of many prokaryotes are known to have a circular structure. In this study, we regard DNA as a knot, ignoring the double-stranded structure, and study the topological property as a mathematical object in the 3-space.

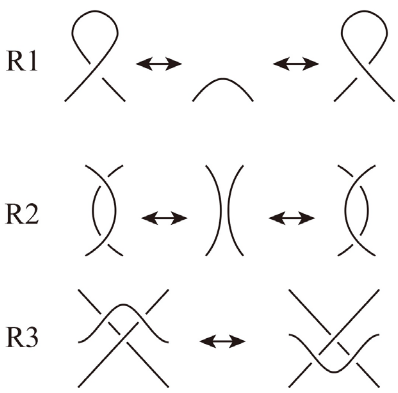
DNA topoisomerases is a general term for enzymes that cleave and recombine one or both double-stranded DNAs. These are essential for DNA replication, transcription, and recombination. In this study, we consider the following recombination of DNA.



[Figure 3: A recombination of DNA]

§3. Tricolorability

Definition 3.1. The following deformations R1, R2, and R3 for a knot diagram are known as *Reidemeister moves*.



[Figure 4: Reidemeister move]

If two knot diagrams can be transformed to each other by a finite sequence of Reidemeister moves, then they are defined to be the *same* knots. Moreover, a value that is defined for each knot and is independent of Reidemeister moves is known as a *knot invariant*.

The definition of tricolorability of a knot is given as follows:

Definition 3.2. A knot is *tricolorable* if each strand of a knot diagram of the knot can be colored one of three colors, subject to the following rules:

1. At least two colors must be used in the knot diagram, and
2. At each crossing, the three incident strands are either all the same color or all different colors.

It is well known that the following theorem holds.

Theorem 3.3. Tricolorability is a knot invariant.

Example 3.4. A trivial knot is not tricolorable because it has a knot diagram, as in Figure 2, which does not satisfy Condition 1 as in Figure 5.

Remark 3.5. (1) A trivial knot is not the only knot that is not tricolorable since the figure-eight knot is not tricolorable.
(2) We see that a knot is not a trivial knot if it has a knot diagram that is tricolorable.

§4. Structure of the open course

We constructed the open course as follows.

(a) Learning contents
Knots and DNA recombination.

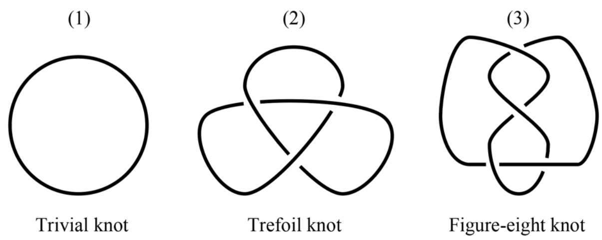
(b) Construction
- Participants
A total of 32 Junior high school students (1st to 3rd grade).

- Leaders
A teacher and three teaching assistants (4th year students).

- Time
90 minutes.

§5. The content of our practice

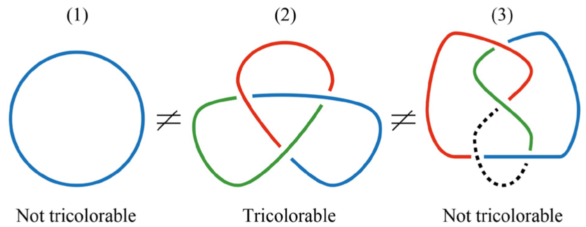
Exercise 1. Are the following knots tricolorable?



[Figure 5: Exercise of Tricolorability]

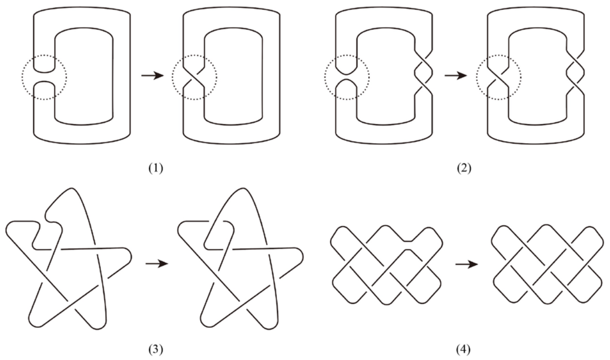
After the exercise, a teacher explained the calculation result about the three knots and promoted the

understanding of tricolorability as illustrated in Figure 6.



[Figure 6: Tricolorability of 3 knots]

Exercise 2. For each DNA recombination from (1) to (4), distinguish knots that appear before and after recombination by using the tricolorability of a knot.



[Figure 7: DNA recombination exercise]

§6. Some scenes from the open course

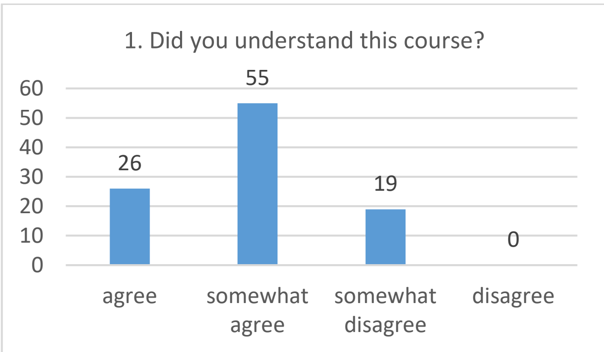
In this section, we review the scenes of the open course with some photos. A teacher and a student showed slides on the screen and participants solved an exercise (see Figure 8).

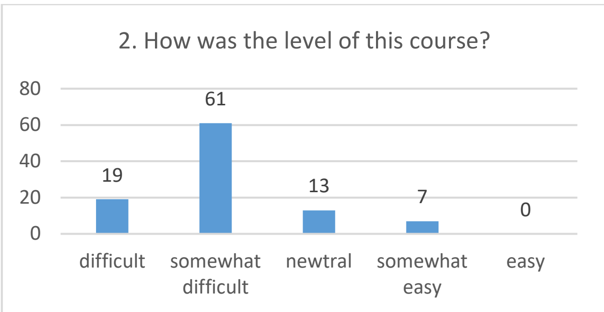
[Figure 8: Open course]

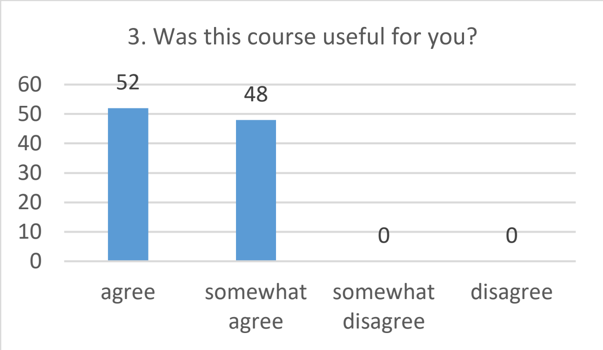
§7. Results of the questionnaire

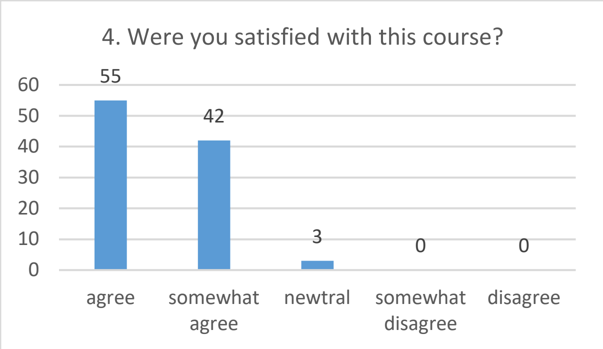
We conducted a questionnaire about our course. The questions and the results are as follows:

Question 1. Did you understand this course?
Question 2. How was the level of this course?
Question 3. Was this course useful for you?
Question 4. Were you satisfied with this course?









[Table 1: Questionnaire responses]

§8. Conclusion of this effort and a future subject

We received the following comments about our open course from participants.

- The course was interesting because it was a field I didn't usually study.
- It was a little difficult, but I realized that mathematics can be used for various purposes. (Knots, DNA, etc.)
- The teacher's explanation was easy to understand and it was a fun course. When I was in trouble because I didn't understand it, I was able to understand it because a teacher and a student taught me about it.
- Unlike usual mathematics and science, I was able to get to know each problem deeply. I'm glad that I found that it was easy to understand and fun to connect with various things.
- After taking today's course, I thought that I wanted to learn more about DNA at college.

The questionnaire demonstrated that our course was effective for the learners and showed potential as a STEAM teaching material.

We now describe teaching materials for use in the future. Knot theory is easy for beginners to understand since it is not necessary to know its background well and there are various teaching materials in which they can learn visually. Knot theory is associated with various fields, such as quantum field theory in physics and molecular design in chemistry and DNA in biology. In the future, we wish to create STEAM teaching materials related to physics and chemistry.

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Attempt of Guidance of Application for Employment by Business people in charge of human resources working for IT companies

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Abstract

From corporate and university internships to employment and advancement activities, until deciding on a career path after graduation, it is required that faculty members along with diverse professional individuals are involved in career education. The application form (AF) is a document created by the students themselves during this period and is an important document that influences the subsequent success or failure of the students' careers. Human resources staff read this "student's letter of introduction," which is the AF, and perform the first screening to welcome them into their organizations. However, the current situation is that there is no guidance on the preparation of such an important document, just some clerical corrections by faculty members. Therefore, in this study, we examined the AF guidance and its effects from the viewpoint of the staff in charge of human resources in information technology (IT) companies through industry–academia–government collaboration.

The participants in this initiative are from Shimane Prefecture, our school, two career consultants, four IT companies and 37 students. The purpose is to stimulate human resource exchanges between IT companies in Shimane Prefecture and students. Shimane Prefecture bore all the costs of the project. The content of the guidance was preparation for AF-writing by two career consultants, AF correction by business professionals (two rounds), and an opinion exchange meeting. To protect the personal information of students, their names and addresses were anonymized. The guidance focused on "motivation for application" and "working hard during studies," which is especially important in the descriptive items of general Japanese AFs.

In the guidance, students learned from two career consultants the significance of the application form and how to draw out what they did best during their studies. After that, a self-analysis was conducted and an AF was described. Although students tend to feel that they do not have the material to market themselves, they received specific suggestions and encouragement from business professionals directly about the descriptive content as well as aspects of grammar in an AF correction and discussion meeting. It was effective for preparations for employment/advancement activities.

Keywords: *Guidance, Application for employment, Bisiness people, Correction, Industry-academia-government collaboration*

Introduction

Students enrolled in the National Institute of Technology (KOSEN) hope to find employment or higher education, such as admission into a university, after five or five-and-a-half years of study. As the grade progresses after enrollment, the students are gradually given career education, and after a company/university internship in the fourth grade, they diligently engage in job hunting from the spring of the fifth grade (final grade) and receive a job offer from companies and pass the university exam. General job-hunting goes through the following stages: (1) the application form (AF); (2) an aptitude test; (3) an interview with personnel staff; and (4) an interview with officers. The first hurdle for students is to submit an AF to the company. An AF includes details about the applicant's motivation to join a company, a description of their personality, and what they did during their student days. As an AF is an important document for the personnel staff of a company to assess a student for hire, it should be well written and consist of details of events and achievements the students have accomplished. Therefore, guidance on writing an AF is critical in students' career education. At Japanese universities, a career support center is often in charge of guidance on AF writing. In KOSEN, there are cases where a career support center is set up similar to a university. The guidance on writing an AF is given as a lesson or a lecture as a part of a few advanced courses. Even if there is some guidance for AF writing, it is recommended that faculty members review the content of an AFs written by students when they are about to apply to a specific company. In Japan, to enhance career education, along with teachers various stakeholders

associated with the school are asked to collaborate. Therefore, in this initiative, the AF guidance program was implemented in 2021 as a joint project with the local government, the human resources staff of local IT companies, and local career consultants.

The educational outcomes that will be clarified when designing this initiative are as follows: (1) communication between students and human resources staff is realized by the AF-writing guidance given by recruiters, and students feel a sense of accomplishment; (2) students themselves can understand what human resources staff specifically read from the content of the AF; (3) motivation to join a company as a result of self-analysis, an outline of their study achievements, and self-promotion can be summarized in sentences that the student can understand. This paper reports the outline and educational effects of the initiative in the first year.

Methods

Table 1 shows the flow of this initiative. The framework of the initiative was designed by the consensus of the students' homeroom teacher (the corresponding author), the Industrial Promotion Division of the Shimane Prefecture Commerce, Industry and Labor Department, and Will San-in Co., Ltd. The lecture was held in December 2021, the first and second corrections were held two weeks apart in January 2022, and the discussion meeting was held in February 2022. The lecture instruction (90 minutes, face to face, instructors were careers consultants belonging to Will San-in Co., Ltd.) focused on "what I did best when I was a student," which is often asked by potential employers and students have difficulty expressing on the AF. First, the Point, Reason, Example, and Point (PREP) framework and the Situation, Task, Action, Result (STAR) framework of sentence composition were explained, and example sentences of each framework were given. In addition, an exercise was held to apply the basic skills of working adults to identify abilities. Next, to write their version of "what I did best when I was a student," an exercise was conducted to self-analyze students' own studies/qualifications, club activities, part-time jobs, and hobbies pursued after entering KOSEN. Following the students' self-analysis, the instructors explained how to put these elements together in a sentence. Finally, they explained what recruiters understand from the strengths and weaknesses that the students themselves describe.

Table 1. The flow of the attempt

Event	Students	Responsible person
Lecture on AF writing (90 minutes)	Preparation for AF	Careers consultants
First AF correction	Submit to business people and get advice	Business people
Second AF correction	Submit to business people and get advice	Business people
Opinion exchange meeting	Review AF writing and get careers advice	Business people

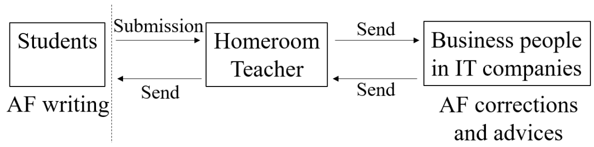

Fig. 1. Flow of AF exchange between the students and the business people in IT companies. Business people cannot see the students' name and address in order to protect personal information.

The AF corrections were made to allow students to create an actual AF and receive advice from recruiters. The IT companies' hiring managers, who cooperated on this initiative, belong to Yakumo Software Ltd., Pasona Tech, Inc. Shimane Lab., Comcre Inc., and Japan High Soft. All companies are located in Matsue city, Shimane Prefecture. Figure 1 shows a schematic diagram of the exchange of AFs. To conceal personal information, such as the student's name and address from the company, the homeroom teacher was in charge of sending the AF files (Excel file) and receiving the corrected files in return. The project management software, Redmine, was used for this transmission and reception. Each student's file was managed with a nickname that the student made up. The AF file was exchanged between the student and the recruiter twice in total. Each recruiter was in charge of correcting, on average, about nine students' forms. Finally, opinions were exchanged (90 minutes) in communication between students and recruiters. This exchange of views was held online using Zoom due to the increase in the number of people infected with coronavirus disease. The student and the recruiter who was in charge of the student's AFs interacted through the screen.

The effect of this initiative was measured by a student questionnaire (35 people, anonymous) and the human resources staff questionnaire (4 people, anonymous). For the questions, a selection type and a free description method were adopted.

Results and Discussion

First, the results of the question on the satisfaction level of the AF instruction for the students are shown and 85.8% of the students responded as being "satisfied" or "somewhat satisfied." As the lectures and corrections were not so different from the usual lectures, it was feared that there would be many negative answers. However, it appeared that the students had a generally positive impact from this initiative. Figure 2 depicts the answers to the question "Which choice impressed you in this activity?" and 63% of the students chose the correction, which is the primary concern of this attempt. Many of the reasons for this were "because I was directly instructed by a business person" and "because I was directly instructed

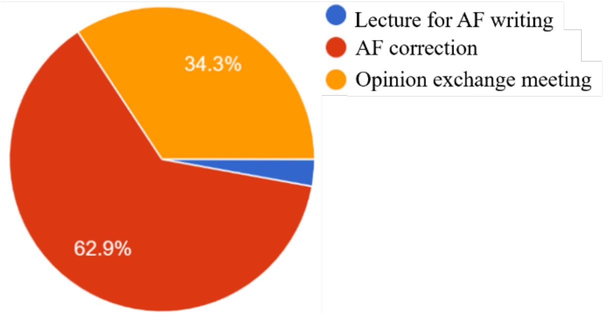

Fig. 2. The answers for the questionnaire "Which choice do you impressed in this activity?".

on my motivation for application and methods of self-expression using my specific content" through the correction of AFs. It is thought that the sense of accomplishment in the students' activities was promoted by the guidance of business advisors rather than teachers and family members.

Figure 3 depicts the answers to the question "How was the communication with business people in the correction guidance?" to which 83% of students said it was "just right," while 17% said it was "a little difficult." The reason they found it difficult was that the only means of communication prepared was to exchange AF twice. As a result, the students probably had difficulty interpreting the comments made during the corrections. Through the corrections, students need to understand and describe what the business person deduces from reading the AF. In the next fiscal year's efforts, we plan to introduce a Web chat service that allows students to understand the reading intentions of business people by communicating with them during AF guidance.

Figure 4 depicts the answers to the question "How was the number of corrections?" While 77.1% of students answered "just right," 17% requested three corrections. This means that some students actively polished their AF in response to the practical and polite recommendations of advisors. Some respondents said, "I wanted to write a perfect AF with repeated corrections." Therefore, it is probable that most of the students, including the students who answered that it was just right, appreciated the significance of the two revisions and tried to get a more convincing feeling. In the next fiscal year's efforts, we plan to make three rounds of corrections.

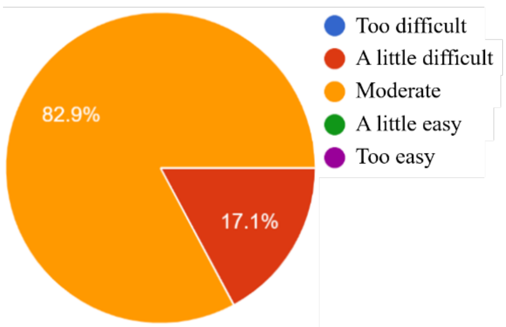

Fig. 3. The answers for the questionnaire "How was it to communicate with IT company employees in the correction guidance?".

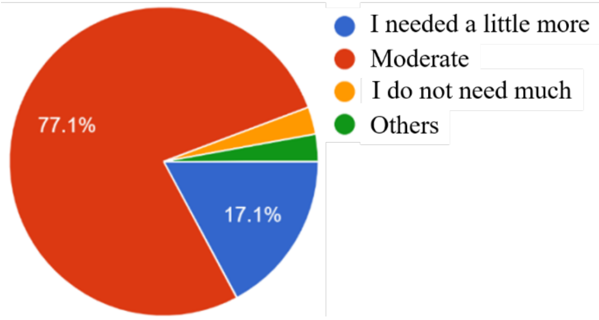

Fig. 4. The answers for the questionnaire "How was the number of the correction?".

At the discussion meeting, the students had a dialogue for the first time through the screen with the business individuals who had made the corrections. The advisors answered questions about the company and the experiences of working in it. In addition to answering questions, the business people gave tips on how to write an AF and tips on selecting a company at the time of job hunting. However, about only 30% of all students asked questions. The advisors had a slightly negative impression of the small number of questions from the students. Many students in KOSEN are not accustomed to discussions, so it is considered that some communication training is needed on asking questions in public without hesitation.

Conclusions

In this study, the AF guidance program was implemented as a joint project with the prefecture, business people in charge of human resources working for local IT companies, and career consultants. Through this initiative, the following are clarified in each item of the educational effect intended at the design stage: (1) the students received AF guidance and felt a sense of accomplishment; (2) it was necessary to improve the communication between students and advisors to ensure that the students can understand how recruiters interpret the contents of an AF; (3) many students were satisfied to compose sentences that the students themselves could understand about the motivation to join a company, what they did during their studies, and self-promotion; this was a result of the self-analysis activities. However, 20% of students requested additional corrections to further improve their AFs. In the next fiscal year, we plan to support such ambitious students by making three rounds of corrections with advisors.

Acknowledgement

In carrying out this research, we received the generous support of the Information Industry Promotion Office, Industrial Promotion Division, Commerce, Industry and Labor Department, Shimane Prefecture. In addition, this study was supported by JSPS KAKENHI Grant Number JP22K02822 (Grant-in-Aid for Scientific Research (C)).

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Self-directed research (2): How do we leave no student behind?

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Abstract

Since the introduction of "Self-Directed Research (SDR)" into its regular curriculum in 2015, Hachinohe Kosen has seen a series of reforms, on a 2- to 3-year basis, on how to implement the year-long student-centered research education. SDR is designed for students to develop not only problem-solving skills but also problem-finding ones. That is a big challenge for lower-year students (1st to 3rd year students, typically aged 15 - 18 years), the number of which is well over 500. For us teachers appointed as coordinators, "leave no student behind" in the innovative research education is a big challenge. In this study we report how SDR in the last academic year (AY 2021) was implemented, focusing on "Facilitating hour (FH)", a kind of student peer discussion chaired by facilitator students qualified from higher-year (4th to 5th year).

Keywords: *Self-directed research, problem-finding skill, problem-solving skill, academic quarter system, coordinator, facilitator student, student peer discussion*

Introduction

The academic year 2021 marked the seventh year since Hachinohe Kosen introduced a year-long research education called "Self-directed research (SDR)" into its regular curriculum (Nakamura 2016[a,b]; Nakamura et al., 2017, 2019; Takeo et al., 2019). Under its academic quarter system, spring and summer quarters are designated for students to concentrate on problem-finding. Students who try but fail to find their own original research subject by the end of summer had no choice but to continue problem-finding in fall quarter, resulting in significant reduction in time to concentrate on the next phase of SDR, i.e., problem-solving. That used to be typical of many lower-year students (1st to 3rd year students, typically aged 15 - 18 years).

From AY 2018, monthly events to support the problem-finding activities, "SDR day (自主探究 Day)" had been held in spring and summer quarters. The lower-year students, the number of which is well over 500, had opportunity to consult teachers about their SDR ideas and plans at "consultation booths". A variety of booths were temporarily set up across the campus on SDR days. Thanks to the events, all students "appeared" to successfully identify their research subjects by the end of summer quarter. It was found, however, that quite a few students afterwards changed their research subject repeatedly. It went like this: They quit the problem-solving halfway, switched to another research subject, quit it halfway, ..., practically leaving the subject "undecided" during a substantial part of fall quarter. While the SDR days were surely beneficial to the students, just those were not enough to serve as a "safety net" for the students.

It should be noted that since AY 2018, about 40 qualified higher-year (4th to 5th-year) students have been appointed as "SDR facilitator students" to help lower-year students proceed with their SDR. On SDR days, consultation booths by facilitator students were set up in addition to those by teachers. The facilitator students, for example, carefully guided lower-year students in the choice of teachers based on whether the teachers' expertise is closely related to the research area of the lower-year students. So, they had mainly played an "indirect role", such as "to help teachers help lower-year students". Regarding SDR, however, facilitator students are much more experienced compared to the teachers in that they had actually experienced SDR as lower-years.

In order to make the most of their potential to directly help lower-year students based on their SDR experience, "Facilitating hour (FH)", a kind of student peer discussion chaired by facilitator students, has been newly installed in the annual events of SDR since last AY2021. In this study we report how FH was implemented and how it worked as a "SDR safety net".

Facilitating hour (FH)

Table 1 shows SDR 2021 schedule focusing on important meetings of the lower-year students. "Activity 0" is for guidance targeting all the 1-st year students. "Activity 1" is a kick-off meeting participated by all the lower-year year students at each class room. Printed copies of AY 2021 SDR manual (Figure 1) were distributed to each student at Activity 1. The students read through important pages of the manual with SDR coordinators (about 10 teachers appointed to engage in planning and management of lower-year students' SDR).

Table 1 SDR 2021 schedule focusing on important meetings of the lower-year students.

Period	Date		Sch.Yr.	Events
Problem-finding (spring & summer)	Apr	20	1	Activity Ø *Guidance*
		21	1, 2, 3	Activity 1 *Kickoff meeting*
		28	3	Facilitating hour 1
	May	12	2	
		19	1	
	June	15	1, 2, 3	Activity 2 *Presentation of previous research*
		16	2	Facilitating hour 2
		23	1	
		30	3	
	July	7	2	Facilitating hour 3
		14	1	
		20	1, 2, 3	Activity 3 *Presentation of pre-experiment plans*
	Aug			*Summer holidays*
	Sept	28	1, 2, 3	Activity 4 *Presentation of pre-experiment results*
		30		
Problem-solving (fall & winter)	Oct	20	3	Facilitating hour 4
		27	2	
	Nov	5	1	
		10	3	Facilitating hour 5
		17	2	
	Dec	15	1	
	Jan	12	1	Facilitating hour 6
		19	1, 2, 3	Activity 5 *Presentation rehearsal*
	Feb	21	3	Poster presentation (on line)
		22	2	
		23	1	

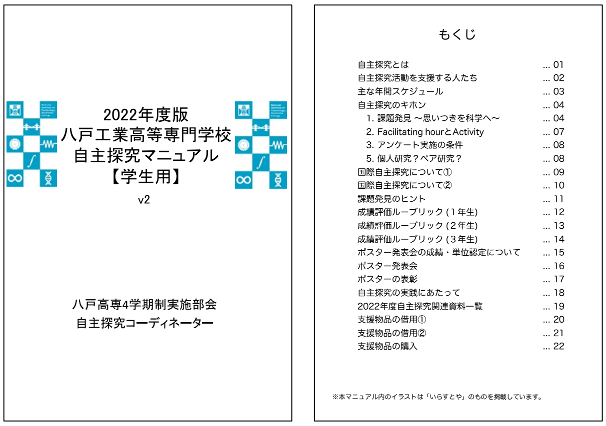
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Figure 1 Cover and a contents page of SDR manual.

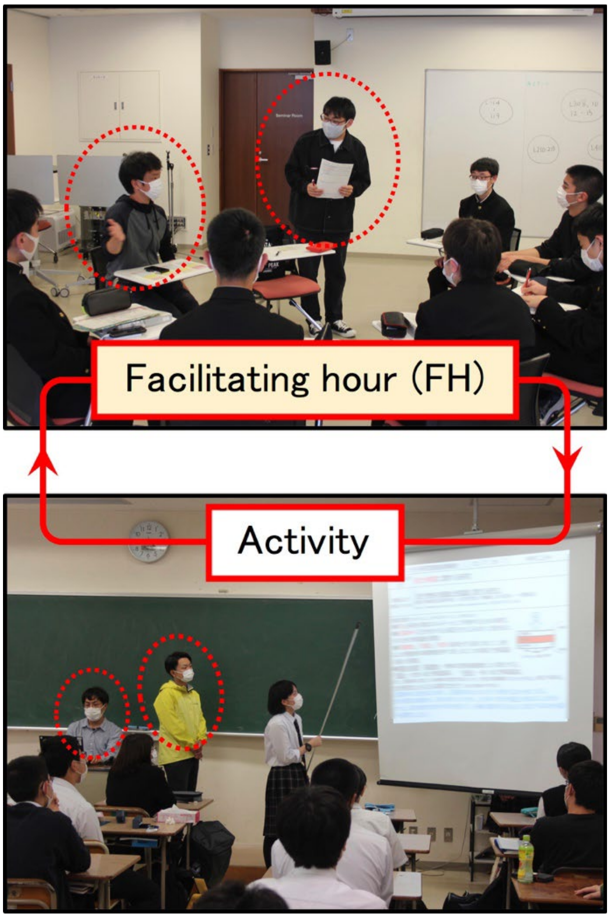

Figure 2 "Facilitating hour (FH)" (upper) and "Activity" (lower). Encircled are facilitator students.

Activity 1 is followed by two series of progress report meetings whose characters are different to each other, "Facilitating hour (FH) 1 to 6" and "Activity 2 to 5", as shown in Table 1. FH is a kind of round table, student peer discussion (Figure 2, upper photo). This 40 minutes FH participated by six lower-year students is chaired by a pair of facilitator students (encircled in the figure). The pair chair three consecutive FHs, in which the lower-year students participating are all replaced each time.

Table 2 shows an example timetable of FH for 3rd year students, for example. Research fields are classified into thirty categories. Time slots are denoted by A, B, and C. A pair of facilitator students assigned to Group 1 chair three consecutive FHs, 1-A, 1-B, and 1-C, each of which is participated by six lower-year students. The number of those participating in any one of the three FHs of Group1, therefore, amounts to eighteen. By deploying ten pairs of facilitator students to form 10 groups, it is possible for all the 3rd year student (about 180) to participate in any one of the 30 FHs scheduled in the timetable. That is also the case for 1st and 2nd year students. The FH dates in Table 1 are thus set separately depending on the school years of the students.

At "Facilitating hour 1" in Table 1, for example, lower-year students report previous research related to

their potential research subject, which is, in general, essential when starting up new research. It should be noted that those students facing difficulties in finding/reviewing previous research are allowed to feel free to consult at FH. Comments, advice, and discussion provided at FH are useful in preparing presentation materials to be used at Activity 2, at which they give a one-minute presentation on previous research they are following and the originality of their potential research subject in front of their classmates at their homeroom classes (Figure 2, lower photo). FH series and Activity series in the SDR schedule in Table 1 are thus designed to be closely related to each other in order for students to be able to proceed their SDR step-by-step.

Table 2 Example timetable of Facilitating hour (FH) for 3rd year students. Colored slots represent research fields.

Group #	A 14:40–15:20	B 15:20–16:00	C 16:00–16:40
1	Health science	Hypnology	Prevention of COVID-19
2	Sports science	Acoustics, phonetics	Audiology
3	Learning methodology	Energy engineering	Chromatics, optics
4	Virtual reality, 3D	Robotics	Programming, AI
5	Mathematical science, physics	Detergency, dehydration	Internet of Things (IoT)
6	Biology, biomimetics	Microbiology	Botany
7	College life, remote learning	Recycling technology	Cosmetology, fragrance
8	Aerodynamics, fluid dynamics	Food & Beverage Science	Stationery invention
9	Ecology, disaster science	Water quality, purification	Ergonomics
10	Regional revitalization	Urban infrastructure	Humanities and Social Sciences

How to most efficiently complete rotation schedules?

The FH timetable in Table 2 requires 20 facilitator students. In 2021 SDR schedule in Table 1, there are 15 days appointed for FH. A cumulative total of 20 x 15 = 300 facilitator students a year is required to implement FH series.

Each of Activities 1 to 5 in Table 1 is implemented in the lower-year students' homeroom classes, the number of which is 12 in total. Two facilitator students are assigned to each class. A cumulative total of 2 x 12 x 5 = 120 facilitator students a year is required to implement Activity series. In order to implement both FH series and Activity series, therefore, a cumulative total of 420 facilitator students a year is required.

There are 40 facilitator students in AY 2021 (Figure 3). There are 420 slots to be filled with their names. Their rotation schedules have to be carefully completed because their own academic schedules have to be prioritized. While online-based schedule management applications seem useful, it takes many days to complete the schedule. While a "face-to-face" meeting to complete the schedule seems a bit "analogue" (Figure 4), draft schedules were completed within less than 40 minutes.

Figure 3 Facilitator students (seven absent from photo).

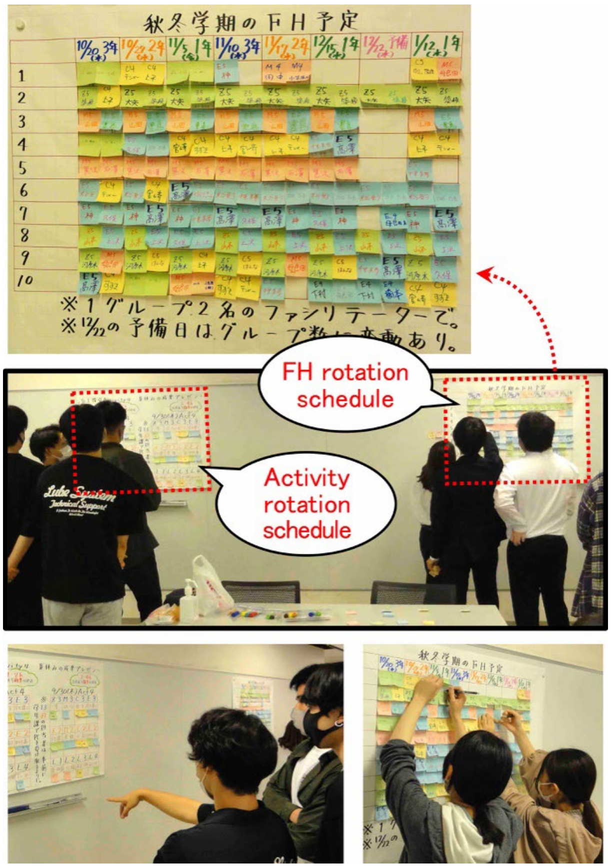

Figure 4 Upper most: Example draft of FH rotation schedule. Middle and lowermost: facilitator students' meeting to complete draft rotation schedules of FH and Activity.

Conclusions

"Facilitating hour (FH)", a kind of student peer discussion chaired by facilitator students qualified from higher-year (4th to 5th year), has been newly installed in the annual events of Hachinohe Kosen's Self-Directed Research (SDR) since AY 2021. FH has been implemented on a continual basis through the year. Until AY 2020, there had been quite a few students who had changed their research subject repeatedly, leaving the subject "undecided" during a substantial part of fall quarter. In AY 2021, such students were hardly seen. FH has successfully served as a "SDR safety net".

It should be noted that the idea of FH was originally hinted by facilitator students. Recently we have often been asked by lower-year students how to become facilitators, which suggests that the facilitators are becoming a positive role model. In addition, we have recently seen many entrants choosing Hachinohe Kosen for doing SDR. SDR has gradually evolved to be sustainable one.

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"INDUSTRY-EDUCATION-RESEARCH INTEGRATION" THE FUTURE OF SUSTAINABLE APPLIED EDUCATION

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Abstract

The integration of industry, education and research is a characteristic of the Vocational and Professional Education and Training (VPET) sector. It is also the driving force of sustainable VPET development in the Mainland as well as other western countries. The purpose of this study is to devise a practicable framework of "industry-education-research integration" for VPET in Hong Kong.

Making reference to i) enterprise academy set up jointly by renowned enterprises in the Mainland and educational institutions, ii) apprenticeship training facilities in the United Kingdom (UK), iii) industry-education joint projects, and iv) an academic discipline of a sub-degree vocational education institution in Hong Kong, VPET institutions can amalgamate the underpinning successful factors and incorporate a framework of the "Industry-Education-Research Integration" for Hong Kong VPET.

As an illustration of deep integration of industry, education and research can be found in the Enterprise Academy. Industries inject capital and "people" investments to co-design with the education sector to develop learning programmes, jointly design teaching and learning module contents and packages, execute dual professionalism mechanism, formulate industrial standards and qualifications, address industry-specific real-life issues, and host competitions. On the other hand, the degree apprenticeship training in the UK carries similar essence of high-level integration of industry and education. Dual-identity apprentices, students of an University and employee of a manufacturing company, attending bespoke undergraduate or postgraduate applied engineering programmes represents the collaboration spirits between industry and education. This paper will apply case study methodology by describing the characteristics of enterprise academies, "Huawei ICT Academy" and "CLP Power Academy", degree apprenticeship training in the UK, Industry College Programme in Taiwan and industry-education collaboration in Hong Kong.

The conclusions and recommendations of this study are that Hong Kong can take advantage of coalescing industry, education and applied research in the course of talent training by means of making new training programmes or reforming teaching contents by joining hands with industries. By adopting this framework, VPET institutions in Hong Kong are able to provide a sustainable pool of skilful talent to fill the manpower need.

Keywords: *VPET, applied education, industry, applied research, integration*

Introduction

Vocational and Professional Education and Training (VEPT) provides vocational-oriented education and training to trainees to equip them with skills and knowledge for work and for further education. VPET plays a fundamental role in sustaining the societal and economic development in Hong Kong. PricewaterhouseCoopers Limited (PwC) has carried out a comprehensive review of the VPET system in Hong Kong and proposed recommendations to improve the ecosystem of VPET in the region. One of the recommendations is to encourage employers, professional bodies, industry chambers and trade associations to take on more active roles in VPET development and enhance the industry's recognition of VPET (PwC, 2021). In light of the above, the community is calling for high-level integration of industry and education, for instance, the joint establishment of training programmes, training materials, dual-professional trainers, commercialisation of industry-specific real-life projects, industry standards and certification as well as participation in competitions and incubating innovations. This paper intends to study the collaboration of industry and education in different countries in order to crystallise a workable, sustainable framework for "Industry-

Education-Research Integration” for Hong Kong’s VPET institutions.

PRC’s Vocational Education Law Reform of 2022

The Standing Committee of the National People's Congress, China's top legislature, adopted the revision of the Law of the People's Republic of China on Vocational Education on 20^{th} April 2022, effective 1^{st} May 2022. This is the first time the Vocational Education Law has been revised since its first adoption in 1996.

The most appealing and phenomenal review is “Vocational Education should be perceived with equal importance to that of academic education”. Measures will be taken to improve the social status and treatment of technologists and technicians. In addition, the PRC Government proposed that Government departments, sub-vented organisations and private corporations shall install an equal employment environment for VPET graduates.

Further, the Reform promulgated greater participation of enterprises in promoting high-quality vocational education. Enterprises are encouraged to integrate industry with education by deepening cooperation with schools. Enterprises that have cultivated skilled workers and promoted employment will be rewarded with various measures, such as preferential tax and fee policies. In addition, enterprises are encouraged to set up trainee posts for vocational students, take part in the compiling of vocational education textbooks, train vocational teachers, and set up scholarships and grants for vocational students.

Figure 1. Highlights of PRC’s Vocational Education Law Reform

Huawei ICT Academy , Henley Business School, University of Reading, UK and Huawei ICT Academy, Thailand

The Industry-Education Partnership can be traced back to the Human Capital Theory (O’Biren, 1999). The theory suggests matching the needs of the industry to the school curriculum in order to enhance the employability of graduates. An illustration of deep integration of industry, education and applied research can be found in the Huawei ICT (Information and Communications Technology) Academy.

Headquartered in Shenzhen, China and founded in 1987, Huawei Technologies Company Limited (Huawei) provides information and communications technology (ICT) infrastructure and consumer electronics. Huawei started its business by manufacturing phone witches and gradually expanded to telecommunication equipment, network infrastructure, semiconductor chips, artificial intelligence, automation, cloud computing, and consumer products. In 2012, Huawei was the largest telecommunication equipment manufacturer in the world. Currently, Huawei operates in over one hundred seventy countries with approximately one hundred ninety-five thousand employees. Huawei ranked forty-fourth in the Fortune Global 500 (Fortune, 2022).

With the view to seamlessly balance and connect ICT talent supply and demand gap, Huawei kick-started its enterprise-education collaboration project, the Huawei ICT Academy, in 2013 by joining hands with educational institutions to help the development of ICT talent. The project covers the “learning, certification, and employment” training life-cycle. By 2019, Huawei has replicated this successful collaboration model to more than seventy countries, including Southeast Asia, the Middle East, Africa, Europe, and Latin America. As a result, more than nine hundred colleges and universities allied with Huawei and have trained over forty-five thousand students every year. In 2019, the project nurtured thousands of quality ICT personnel to the industry.

As a demonstration of high-level Industry-Education integration, Huawei injected capital and “people” investments to co-design and co-develop with the educational institutions in establishing the “joint” goals, including but not limited to CO-DEVELOPMENT of:

1. learning programmes;
2. module contents, teaching and learning packages;
3. dual-professionals;
4. industrial standards and certifications;
5. solutions to address industry-specific real-life issues; and
6. competitions and innovations

The Huawei ICT Academy at the University of Reading is a training and research centre supported by Huawei and Henley Business School. Established in 2015, it is the first collaboration project in the United Kingdom. In 2019, joint projects included:

1. Co-development of learning programmes

A communication technology professional group was established, and the group jointly developed a number of learning programmes in big data, cloud computing, artificial intelligence and 5G technology areas.

2. Co-development of module contents, teaching and learning packages

In-service professionals jointly developed teaching and learning packages for the Academy by transforming Huawei's 5G data communication, cloud computing and other technical standards into curriculum standards and teaching resources.

3. Co-development of dual-professional teaching team

Huawei has customized training courses for trainers on 5G, network infrastructure, cloud computing, Internet of Things (IoT), and big data. At the same time, Huawei engineers were recruited to coach and guide students to participate in the Huawei ICT Competition.

4. Co-development of industry standards and certifications

Supported by the industry, the Huawei ICT Academy is tasked to deliver three levels of professional certifications, namely Associate, Professional and Expert.

Over the years, thousands of students have passed Huawei's certifications. Certificants were awarded a qualification officially certified by Huawei and were able to have placement opportunities at Huawei.

Figure 2. Speech by Professor Keiichi Nakata, Henley Buiness School, University of Reading, UK

In Thailand, Huawei ICT Academy has collaborated with 25 local universities and colleges to provide a through-train "training-certification-employment" opportunity to help students broaden their ICT knowledge.

5. Co-development of solutions to address industry-specific real-life issues

Huawei is committed to providing quality courses and building labs where the company's ICT technologies, such as 5G, Cloud Computing, IoT and Big Data, are made available to recreate real-life solutions and encourage creativity. (The Nation Thailand, 2021)

6. Co-development of competition and innovation

Huawei has held annual ICT competitions since 2015. To promote learning through competition, the competitions aim to provide platforms for college students worldwide to increase their ICT knowledge, stimulate their innovation capabilities, and improve their self-learning and problem-solving abilities. In the fifth competition in 2020, over seventy countries around the world with more than one hundred and fifty thousand students joined the competition.

Figure 3. Huawei ICT Competition 2019-20

The above paragraphs provide evidence from an enterprise headquartered in China showing high-level integration of industry and education cooperation by replicating successful stories in the UK and Thailand. Our next case is from the WMG Degree Apprenticeship Centre at the University of Warwick, UK.

WMG Degree Apprenticeship Centre, University of Warwick, UK

Founded in 1965, the University of Warwick (Warwick) is a world-leading university with high academic standing and research standard. Warwick is a

member of the Russell Group, an association of 24 major UK research-intensive universities. Warwick is ranked 6th in the UK (The Guardian 2022 league table) and 61st in the world (QS World University Rankings 2022). The WMG Degree Apprenticeship Centre (Centre) was formally opened in June 2021. With a training capacity of one thousand places, the Centre trains apprentices by offering undergraduate and postgraduate degree programmes specialising in sophisticated engineering and manufacturing business.

Equipped with communal spaces to facilitate collaborative and individual projects, the Centre also houses high technology seminar rooms and multifunctional laboratories for project-based teaching and learning.

The degree apprentice programme adopts the part-time day release mode by combining school-based training and workplace learning. The apprentice holds dual-identity, both trainee of the Centre and employee of enterprises, inter alia, Amazon, Aston Martin, Dyson, GE, Jaguar Land Rover, Rolls Royce.

The Centre collaborates with the industry to co-design and co-develop a learning programme suitable for dual-identity apprentices. For instance, the Centre jointly developed a highly technical Bachelor of Applied Engineering programme with Dyson. Likewise, the Centre also deliver Master's level Degree Apprenticeships to Amazon, GE Aviation and Royal Mail Group (Coventry & Warwickshire Local Enterprise Partnership, 2021).

Industry College Programme, Ministry of Education, Taiwan

The Industry-Education Integration Scheme in Taiwan was approved by the Ministry of Education (MoE) in the early 1980s. With the changing industry and social needs, technical and vocational education have to adjust the direction of talent cultivation. Students can learn and develop according to their personal interests, aptitudes and talents. Upon completion of training, VPET graduates quickly integrate with the industry and become applied professionals. In 2014, the MoE launched the "Industry College Programme".

Since then, a total of seventy-eight technical colleges have cooperated with more than one thousand enterprises to implement more than six hundred and twenty academic programmes. Approximately four thousand students were retained by the cooperative enterprises and were employed after graduation. The cooperative enterprises came from a wide variety of industires, including precision manufacturing, aviation, automobile, computer-aided design, healthcare, integrated circuit chips, communications, environmental, business, arts, cultural, hospitality industry etc. The integration of Industry-Education in this Programme is multi-dimensional, (i) provision of learning programmes, (ii) deliver by in-service trainers, (iii) licensing and (iv) employment. The enterprises cooperate with educational institutions to co-develop VPET-oriented learning programmes integrating theory and practice. Upon completion, the graduates can fulfil the academic requirements of a licensed technician. More importantly, the graduates are immediately employed by the enterprises.

CLP Power Academy, Hong Kong

CLP Power Hong Kong Limited (CLP Power), founded in 1901, is a Hong Kong utility company and one of the Asia's largest investor-owned power businesses. CLP Power engages in electricity supply operations in Hong Kong SAR and provides a highly reliable electricity supply to six million people.

Established in 2017, CLP Power Academy is the leading VPET-oriented corporate institution dedicated to the power engineering field. The establishment aims to fill the gap between theory and practical training.

Again, the integration of Industry-Education in this project is multipronged, (i) provision of learning programmes, (ii) deliver by in-service trainers and (iii) setting industry standards. The CLP Power Academy cooperates with five local and overseas educational institutions to co-develop VPET-oriented learning programmes that integrate theory and practice. Seasoned engineers deliver a portion of the modules at their specialised training facilities. Upon completion of the learning programme, the graduates can fulfil the academic requirements of a licensed electrical technician.

Figure 4. CLP Power Academy collaborates with the Vocational Training Council, Hong Kong

Information Technology Discipline, Vocational Training Council, Hong Kong

Owing to the megatrend of digital transformation, smart city and the COVID-19 "new normal" situation,

the Government of the HKSAR has put a strong focus on nurturing IT talent. According to an analysis, the IT industry employed more than one hundred and ten thousand practitioners in 2019, about 3% of Hong Kong's working population (PwC, 2021).

Over the years, VPET institutions nurtured around 42% of the total number of persons engaged in the IT industry in 2019 (PwC, 2021). The Information Technology (IT) Discipline is one of the seven academic disciplines of the Vocational Training Council (VTC), Hong Kong. IT Discipline offers a comprehensive portfolio of learning programmes covering the information and communications technology (ICT) area and the multimedia and entertainment technology (MET) sector. In addition, IT Discipline collaborates closely with IT enterprises, for instance, Alibaba Cloud, IBM and Microsoft, by jointly upgrading the learning programme curricula and module contents.

In addition, students from IT Discipline won prizes in the Smart Kiosk Design Competition, co-organised by the Discipline and a local telecommunication company. The winner students will collaborate with the local telecommunication company to co-design and revitalise traditional payphone kiosks into intelligent kiosks. Hopefully, these smart kiosks will be commercialised.

Figure 5. Intelligent Kiosk

The above paragraphs showcase a triumphant story of a Hong Kong VPET institution by integrating Industry – Education – Applied Research during the provision of training to students.

Socio-Economic Impact of VPET on Hong Kong

Hong Kong has transitioned from a manufacturing-based economy to a knowledge-baed economy (PwC, 2021). VPET plays a fundamental role in sustaining the societal and economic development in Hong Kong. VPET supports Hong Kong's economic development by filling the gap between the demand and supply of skilful talents. Despite the provision of human capital to support Hong Kong's economic development, VPET provides education pathways for upskilling and reskilling of workforces so as to sustain the structural transformation of the economy of Hong Kong.

According to PwC's analysis, VPET providers have trained more than nine hundred thousand graduates in the past three and a half decades, accounting for nearly 24% of Hong Kong's total working population in 2019 (PwC, 2021). In the financial year of 2018/19, VPET providers and their graduates generated a total of HK$97 billion Gross Value Added to Hong Kong's economy, which is equivalent to 3.4% of HK's GDP. However, VPET has yet to be positioned on a par with the conventional academi route. As such, a sustainable model of the VPET ecosystem is of equal importance to the economic sustainability of Hong Kong.

Sustainable Framework for VPET Institutions

This paper aims to devise a sustainable framework for VPET institutions in Hong Kong. Making reference to some models, for instance, Enterprise Academy, Degree Apprenticeship Centre, and Industry College, a Three-Factor Model for Sustainable Framework is crystalised by integrating "Industry – Education – Research". In light of the above, the community is calling for the integration of industry and education. To achieve sustainability, industries and educational institutions should jointly establish training programmes, training materials, dual-professionalism, commercialisation of real-life industry-specific projects, industry standards and certifications as well as participate in competitions and incubating innovations.

Figure 6. Three-Factor Sustainable Framework for VPET

Way Forward

A Four-Factor Model should be proposed with the inclusion of "Government's Funding" support. Since 2014, the Government of the HKSAR has collaborated with the VTC to introduce a tripartite participation scheme called the "VTC Earn & Learn Scheme", wherein the Governments provide financial incentives to industry employers to help the employees to have school-based training and workplace training with guaranteed monthly income. Since the Scheme's launch, more than five thousand seven hundred apprentices have benefited from this project. This Scheme significantly solves the manpower shortage issues in industries, especially construction, lift and escalator maintenance.

In Australia, Finland, Germany, Switzerland and the UK, the Government provides either tax concession or substantial expenditure to support VPET. Looking forward, the Three-Factor Model should be extended to a Four-Factor Model by injecting Government support to make the VPET ecosystem more sustainable.

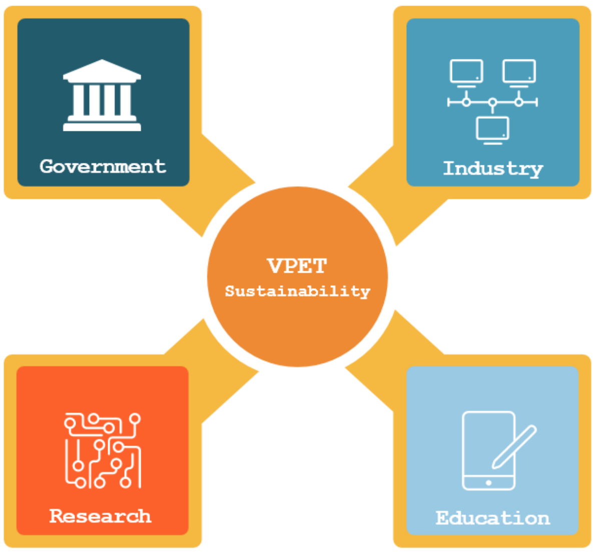

Figure 7. Four-Factor Sustainable Framework for VPET

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IMPULSIVE REPEATED SNOW COMPACTION FOR SNOW REMOVAL ASSIST

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Abstract

Snowy countries in Japan have social issues about the labor shortage, population aging, and population decrease; Ishiguro et al. (2017), Ishiguro et al. (2020). In this work, a snow consolidation property has been investigated to establish a method to safely consolidate the huge amount of snow into an ice brick in a few minutes to avoid disposal transportation of overflow storage snow to assist in snow removal. Especially, the impulsive force effects on the increase of snow compaction density were evaluated. In the test, shaved ice imitating natural snow was impulsive and repeated consolidated for several $N = 1^{st}–5^{th}$ times by mechanical press machine at experiment ambient temperature $T \leq 7$ °C. And axial formation speed was set as $v = 250$ mm · min^{-1} corresponding snow consolidation strain rate $\acute{\varepsilon} = 5.00 \cdot 10^{-2}–1.20 \cdot 10^{-1}$ s^{-1}. This experimental strain rate was 1,000 times larger compared with the natural snow consolidation process. This work discussed the possibility of the snow compaction process by lower formation force using impulsive force. For that purpose, snow consolidation pressure, backpressure on the pressure vessel lateral wall, and position of formation platen were continuously measured during the test. Then the deviatoric stress of horizontal direction σ_H' and vertical effective stress σ_V' were evaluated. And the coefficient of lateral earth pressure at rest K_0 has been evaluated. The K_0 was defined by the calculation of σ_H divided by σ_V. By the result, it was found that the backpressure vibration occurred in the height direction of the pressure vessel at all of $N = 1^{st} – 5^{th}$. And the final snow consolidation density ρ_5 became 0.880 g·cm^{-3}, and it was increased by almost 240 % by those impulsive and repeated compressive deformations compared with its initial density. And the maximum backpressure on the pressure vessel lateral wall became almost twice compared with maximum axial formation pressure. It would be able to design a safety snow consolidation machine based on using this reported coefficient of lateral earth pressure at rest K_0.

Keywords: *Stress relaxation. Heterogeneous deformation. Aging of population. Labor shortage issue. Later stage society issue.*

1. Introduction

It was known that the aging population and its turning into a later stage society has become a social issue in Japan; Ishiguro et al. (2017). For instance, recently, some elderly persons already were not able to escape by themselves after weeks of snowfall, and after they were locked in the house for a few days. And it was known that some elderly persons have chronic problems disposing of huge amounts of snow by themself, although they have some blower or dozer-type snow removal machines. For instance, in the disposing process, some vehicles are needed to transport huge amounts of snow. And operators must pile up the snow onto trucks by human power or using the agriculture or construction small dozer. General later stages elderly persons cannot do that by themselves due to aging. From such background, in the previous report; Ishiguro et al. (2020), in-situ snow consolidation process of the huge amount of snow has been proposed for helping those snow disposal process. The process can consolidate a huge amount of snow and disposes of it in-site by a minimum number of operators. And the process does not need snow disposal transportation. Of course, it can consolidate snow before being it onto the truck when disposal transportation will be needed. In previous research, unexpected some pressure vessels were broken during the laboratory snow consolidation verification test. From such a background, the axial formation pressure and the backpressure on the pressure vessel lateral wall were especially measured during snow consolidation tests for safe usage of the proposed process. And the coefficient of lateral earth pressure at rest K_0 has been evaluated. In this report, the effect of impulsive force on the increase of snow compaction density ρ and the coefficient of K_0 at impulsive and repeated snow consolidation process was investigated, and its result was reported.

2. RESEARCH CHALLENGE OF SNOW CONSOLIDATION

Heretofore, some investigations about the snow consolidation were performed by some researchers;

Maeno et al. (1983) and Ebinuma et al. (1985). Those researchers performed experiments for -25 °C and strain rates at $\acute{\varepsilon} \approx 10^{-7} - 10^{-5}$ imitating natural snow consolidation deformation in the Antarctica atmosphere. It was thought that the snow consolidation had local deformation, but in order to avoid the immaturity of the general measurement technology at that time, and to easily understand the phenomenon, uniform deformation was assumed. There are a few studies that assume uniform deformation of snow or ice for similar reasons; Wang et al. (2018), and Ishiguro et al. (2017).

But some researchers thought that the highly porous matrix of ice or snow is certainly heterogeneous material; Szabo et al. (2007), Reiweger et al. (2009), Cappelli et al. (2018), Cappelli et al. (2020). Szabo et al. (2007) showed the local bonding of ices by recrystallisation was done under sub-second. It became the evidence to support that the local exfoliation and re-bonding have occurred during ice or snow deformation. Reiweger et al. (2009), Cappelli et al. (2018), and Cappelli et al. (2020), the international joint team showed the computer simulation using fiber bundle modeling (FBM) can predict snow tensile test behavior. Those research results indicated that the snow deformed partially and was heterogeneous, and the local exfoliation and re-bonding or healing by recrystallisation occurred under sub-second.

At present, the heterogeneous snow deformation has been directly observed using a high-performance computer and artificial intelligence technology; Thomas et al. (2017), Ueda (2022). Thomas et al. (2017) visually showed the deformation strain bands in snow consolidation using Digital Image Correlation artificial intelligence technology (DIC). In fact, snow does not deform uniformly, if anything, snow deformed locally and heterogeneously. And the heterogeneous deformation patterns were obviously changed with formation speed and experiment apparatus dimensions. Ueda (2022) obtained repeatability of Thomas' research result at follow-up research using original DIC using general the AKAZE open-source library, especially, the author presents his whole Python program. As described above studies, have shown snow heterogenous deformation using strain distribution. It was known that stress is an important factor related to snow deformation as another factor. Heterogenous stress distribution had been given by Ishiguro et al. (2020). The authors have researched the snow consolidation pressure vessel's unexpected breakage by the heterogeneous stresses.

Heretofore, some investigations about the strength integrity of pressure vessels were performed; Faupel (1956), Manning (1978), Faupel (1979), Hamada et al. (1986). Conventional research performed hydraulic pressure tests or FEM analysis assuming isotropic deformation of the inner material. But, in fact, unexpected pressure vessel breakage has occurred nonconforming the conventional assumption. The reason was thought that the inner compressive material has heterogeneous deformation properties opposing isotropic deformation assumption as described above. Therefore, in this report, the authors evaluated the deviatoric stress of horizontal direction σ_H' and vertical effective stress σ_V'. And the coefficient of lateral earth pressure at rest K_0 has been evaluated using those effective stresses. And the effect of impulsive force on the increase of snow compaction density ρ was investigated, and its result was reported.

3. IMPULSIVE SNOW CONSOLIDATION PROCEDURE

This study consolidated shaved ice imitating natural snow using a closed die as a pressure vessel. Dimensions of the snow consolidation pressure vessel was shown in **Figure 1**. The pressure vessel has 12 points very small load cell (PS-D; Kyowa Corp.) in the height direction of the lateral wall of it. The sensor has a 6 mm diameter pressure plane, and maximum measurement pressure range is 7 MPa, and the category temperature range is -20 − 70 °C. And the cross-section of the consolidation pressure vessel was square. In the experiment, the axial formation force during the test was measured using both the machine and external load cell (LC-1250; A & D Corp.). And the position of the snow consolidation upper platen was evaluated by the ram position of the machine. The experiments were performed by the a number of trials times of 30.

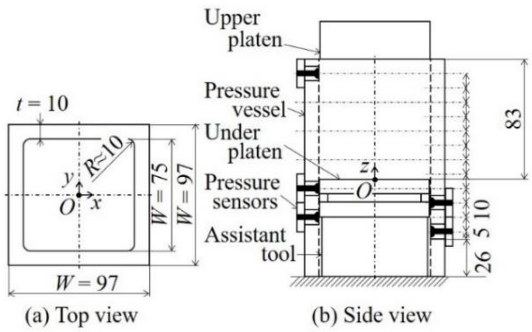

Figure 1. Dimensions of snow consolidation pressure vessel.

A schematic illustration of the impulsive snow consolidation procedure was shown in **Figure 2**. First, the height position under the platen was adjusted for $H/W = 1.1$ using the assistant tool as shown in **Figure 2 (a)**. Here, H = 83 mm and W = 75 mm are initial filling representative height and width of the pressure vessel, and origin O was shown in the figure. Then shaved ice was filled into the consolidation pressure vessel as shown in **Figure 2 (b)**. Previous reports said that the shaved ice size was suitable to imitate natural snow material properties; Ishiguro et al. (2017), and Ishiguro et al. (2020). Then movable upper platen was settled on the filled shaved ice as shown in **Figure 2 (c)**. Then the shaved ice was consolidated by the impulsive compressive force for the number of N = 1st to 5th as shown in **Figure 2 (d)** using a universal material test machine (Autograph AG-X with control software Trapezium; Shimadzu Corp.). During the tests, the apparatus temperature was kept to $T = 0 - 7$ °C, and snow

melting was not almost observed. The snow consolidations were performed up to maximum axial formations pressure p_{z_max} = 0.5 MPa by constant formation velocity v = 250 mm·min^{-1}; it is the maximum deformation speed of the test machine. And the initial snow consolidation strain rate $\acute{\varepsilon}_{ini.}$ = 5.00 · 10^{-2} s^{-1}, and it became larger after starting test, and the final strain rate become the $\acute{\varepsilon}_{fin.} \approx$ 1.20 · 10^{-1} s^{-1} at end of the consolidation of N = 5th. Then the deviatoric stress of horizontal direction σ_H' and vertical effective stress σ_V' were evaluated by stress analysis based on obtained measured data. And the coefficient of lateral earth pressure at rest K_0 has been evaluated.

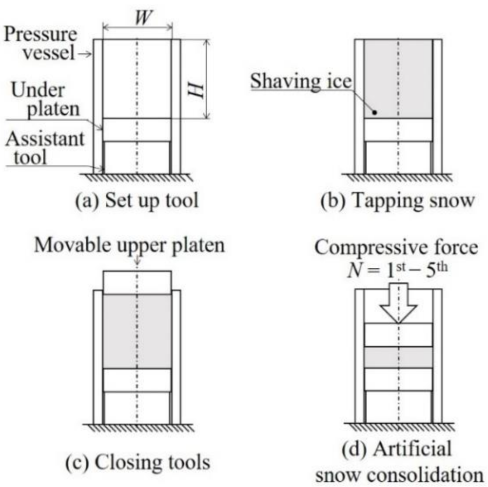

Figure 2 Schematic illustration of impulsive snow consolidation procedure.

4. AXIAL FORMATION AND BACKPRESSURES AT IMPULSIVE SNOW CONSOLIDATION

The impulsive snow consolidation properties were evaluated. First, almost 90 % results of the tests showed that the backpressure occurred around the bottom of the pressure vessel. And the result has good agreement with previous reports by Ishiguro et al. (2020). Relations among axial formation and backpressure and testing time are shown in **Figure 3**. The maximum axial formation pressure was given by p_{z_max} = 0.5 MPa, but the measured p_{z_max} was over the set value. The reason was that the impulsive force was caused by the machine's inertia release at the bottom dead center, and it was far exceeding compared with set force value. After the end of deformation, both pressures returned to 0.0 MPa by stress relaxation. The snow compaction average heights H_f were shown in the figure. In the repeated impulsive snow consolidation, the snow compaction densities were increased as ρ_0 = 0.373 g·cm^{-3}, ρ_1 = 0.801 g·cm^{-3}, ρ_2 = 0.841 g·cm^{-3}, ρ_3 = 0.847 g·cm^{-3}, ρ_4 = 0.860 g·cm^{-3}, ρ_5 = 0.880 g·cm^{-3}, respectively. And the measured maximum axial formation pressure increased to 130 %.

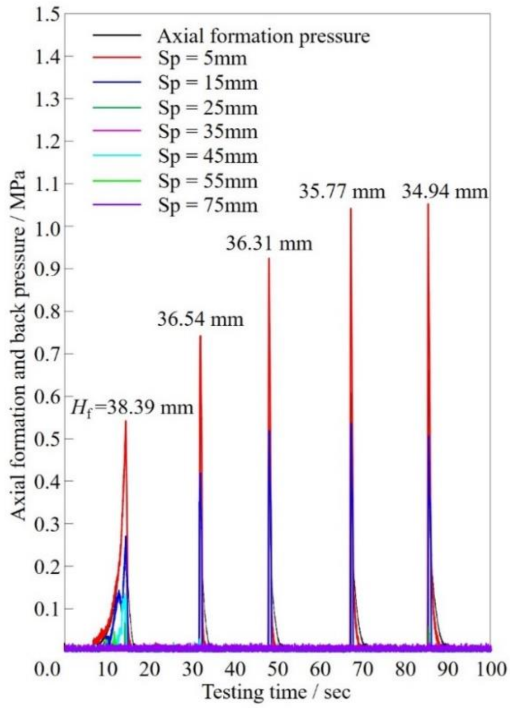

Figure 3. Relations among axial formation and backpressure and testing time.

The relations between axial formation and backpressure and testing time for N = 1st are shown in **Figure 4**. Obviously, a different phenomenon was measured compared with the previous report by Ishiguro et al. (2020). That is that the backpressure vibrated along the pressure vessel wall in the whole height direction. Those phenomena were not measured in the previous report for v < 200 mm·min^{-1}.

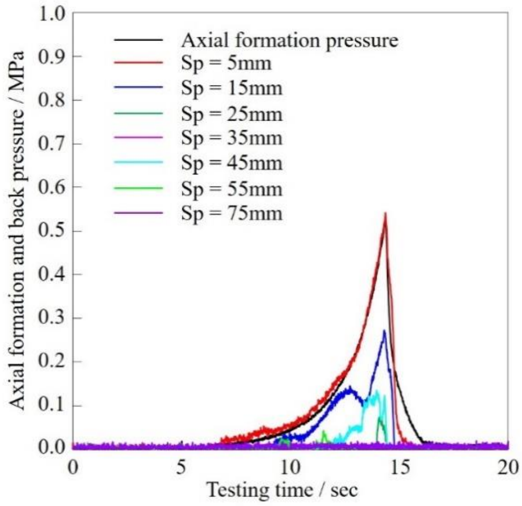

Figure. 4. Relations between axial formation and backpressure and testing time for N = 1st.

Then the result of N = 5th was compared with that of N = 1st. The relations between axial formation and backpressure and testing time for N = 5th is shown in **Figure 5**. The axial formation pressure increased by almost 130 % more than the set formation pressure by the

inertia release, but its abnormal vibration was not measured. And backpressure at S_p = 5 mm was almost twice the set formation pressure, and the backpressure almost occurred only around the pressure vessel bottom that the result has good agreement with the previous report by Ishiguro et al. (2020). It was found that whether stress vibration occurs or not among the whole height direction of the pressure vessel was changed with the test conditions. It was re-realized that the snow consolidation needs multiple point pressure measurement for safety design and usage of equipment.

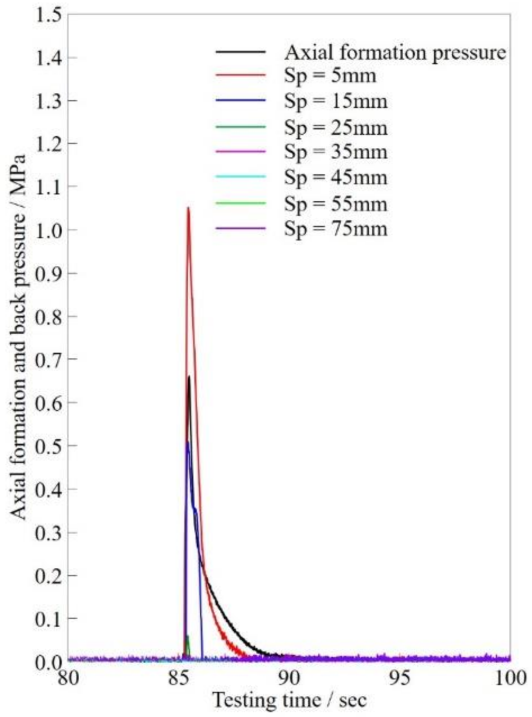

Figure 5. Relations between axial formation and backpressure and testing time for N = 5th.

The reason for the unexpected pressure vibration and the lopsided occurrence of intense backpressure had not been known. First, it was thought that the reason of that the backpressure vibration occurrence was caused by compressed air in the inner material. But the leaked air sound pressure level was weak, and it was not corresponding to the measured internal pressure level. Therefore, it was thought that unknown reason contributes to the phenomena. But, during the investigation, it was pointed out by another international research team that the occurrence was caused by local deformation hardening and softening of the snow; Thomas et al. (2017). The research team used AI-Digital Image Correlation (DIC) using a high-speed camera for observation and quantitative evaluation of the planer strain of the snow during its consolidation process. And it was shown that the snow showed nonlinear and local deformation behaviors during the snow consolidation deformation, and its planer strain band in the snow and its vibration using a visible image result. And those phenomena were also observed in natural snow using AI-DIC for the evaluation of plane strain by Gaume et al. (2018). Detail explanation of DIC has been shown by Sindre et al. (2020_1) and Sindre et al. (2020_2).

5. EVALUATION OF THE COEFFICIENT OF LATERAL EARTH PRESSURE AT REST K_0

Then a stress analysis of S_p = 5mm, which had the highest backpressure, was performed. Especially, deviatoric stress was evaluated as effective stress acting on the inner material; Kikumoto et al. (2015). Deviatoric stresses σ_H' and σ_V' of the compressive snow at S_p = 5 mm were evaluated. But the obtained experimental data became a reference value, because the material volume changed during the test, and it is not suitably adapted to the material as general deviatoric stress at plastic deformation analysis. Here, the deviatoric stresses were defined as follows.

$$\sigma_H = -P_b \quad (1)$$

$$\sigma_V = -P_z \quad (2)$$

$$\sigma_H{}' = \sigma_H - \sigma_m \quad (3)$$

$$\sigma_V{}' = \sigma_V - \sigma_m \quad (4)$$

$$\sigma_m = -\frac{p_b + p_b + p_z}{3} \quad (5)$$

Here, σ_H and σ_V are horizontal and vertical direction stresses of the material, respectively. And the σ_m is mean normal stress of the material. p_b and p_z are backpressures from the lateral wall and formation pressure from platen acting on the material. And it was assumed that the σ_H equals σ_x and σ_y, and σ_V equals σ_z, respectively.

The relations between deviatoric stresses σ_H' and σ_V' for S_p = 5 mm and N = 5th is shown in **Figure 6**. The axial, lateral, and its mean normal stresses have minus values, and it meant those were acting on the inner material as compressive stress. And the absolute value of axial stress σ_z became larger by 0.5 MPa by impulsive inertia force. Lateral stresses σ_b became over twice than set axial formation stress. The deviatoric stress σ_V' showed a positive value, the result goes against the fact that the platen is descending. It is conceivable that the reason for that is probably due to the inner material volume change. In any case, the deviatoric stress seemed difficult as a factor to use in the calculation of the coefficient of lateral earth pressure at rest K_0. Therefore, this report uses σ_H and σ_V for calculating K_0, and it seems to be reasonable for a simple understanding of the phenomena. In this report, the K_0 was defined as follows.

$$K_0 = \frac{\sigma_H}{\sigma_V} \quad (6)$$

The value of K_0 at minimum axial formation stress for S_p = 5 mm and N = 5th was K_0= 1.53, and other stresses were σ_H = -1.01 MPa and σ_V = -0.66 MPa.

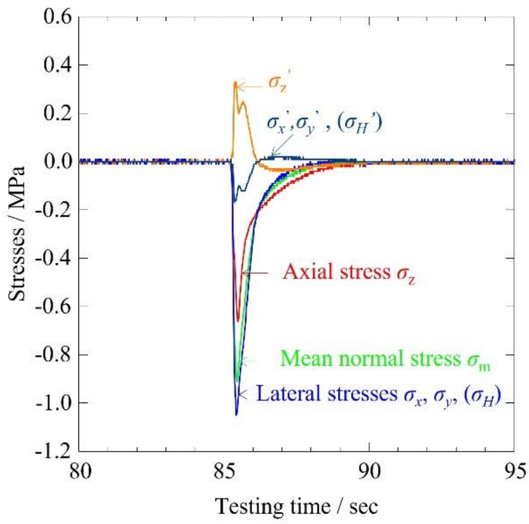

Figure 6. Relations between deviatoric stresses σ_H' and σ_V' for S_p = 5 mm and $N = 5^{th}$.

6. DISCUSSION OF THE COEFFICIENT OF LATERAL EARTH PRESSURE AT REST K_0 AT VARIOUS TEST CONDITIONS

The K_0 at various test conditions was investigated and discussed. The test condition of the p_{z_max} = 0.5 MPa, v = 250 mm·min^{-1} was too rapid and still difficult to safely perform experiments. Therefore, the deformation speed v was changed to v = 200 mm·min^{-1}. And it was known that the p_{z_max} = 0.5 MPa can consolidate snow completely by repeated processes, but it is difficult to complete consolidate the snow at one stroke formation. Therefore, the p_{z_max} was changed from 0.5 MPa to 1.0 MPa for one stroke snow consolidation formation. And the number of test trials was changed from N = 30 to 10. The experiment detail and results were reported; Nakasora et al. (2020). The effect of the initial snow filling ratio H/W on the K_0 values was investigated. The relations between H/W and K_0 was shown in Table 1. The effect of the initial snow filling ratio H/W strongly affected K_0. The K_0 increased as decrease the H/W, and it became 3.51 at the H/W = 0.5, and the probability of the backpressure becoming over axial formation pressure was 80 %. And the K_0 strongly affected the experimental apparatus dimension ratio, and its magnitude was larger than that of the deformation speed effects. It was found that the consolidation of a small amount of snow is accompanied by accidental danger for high probability.

Table 1. The relations between H/W and the coefficient K_0 for p_{z_max}=1.0MPa, v =50mm·min^{-1}.

Initial snow filling ratio H/W	0.5	1.1	1.7
Ratio of backpressure p_b over axial formation pressure p_{z_max} [%]	80	30	10
Maximum back pressure p_{b_max} [MPa]	3.51	2.01	1.35
Coefficient of lateral earth pressure at rest K_0	3.51	2.01	1.35

Then, the effect of the set maximum axial formation pressure p_{z_max} on the K_0 values was investigated. The relations between p_{z_max} and K_0 was shown in Table 2. The H/W was 1.7 in the tests. The relations between p_{z_max} and K_0 was shown in Table 2. It seems that the abnormal excessive backpressure occurrence ratio was not related to change of the p_{z_max}. And the K_0 values deceptively seem large at p_{z_max} =0.1 MPa, but in fact, the maximum backpressure p_{b_max} was small compared with other abnormal results. It was thought that the set maximum axial formation pressure p_{z_max} magnitude does not relate to unexpected abnormal backpressure occurrence by comprehensive insight.

Table 2 Relation between the axial formation pressure p_{z_max} and the coefficient K_0 for H/W=1.7, v =50mm·min^{-1}.

Set maximum axial formation pressure p_{z_max} [MPa]	0.1	0.5	1.0
Ratio of backpressure p_b over axial formation pressure p_{z_max} [%]	20	10	10
Maximum backpressure p_{b_max} [MPa]	1.44	0.638	1.35
Coefficient of lateral earth pressure at rest K_0	14.4	1.28	1.35

Then the relation between the formation velocity and the coefficient K_0 for H/W=1.1, P_{z_max}=0.5MPa was investigated. The maximum K_0 was K_0 = 4.39. The K_0 used in the description above to simplify understanding was K_0 =1.53, but the maximum K_0 in the experimental was K_0 = 4.39. The lateral pressure was strongly affected by formation velocity on the snow consolidation formation.

Table 3 Relation between the formation velocity and the coefficient K_0 for H/W=1.1, P_{z_max}=0.5MPa.

Formation velocity v [mm·min^{-1}]	50	100	150	200	250
Ratio of backpressure p_b over axial formation pressure p_{z_max} [%]	20	10	10	0	40
Maximum backpressure p_{b_max} [MPa]	1.05	1.10	0.70	0.54	2.20
Coefficient of lateral earth pressure at rest K_0	2.11	2.21	1.41	1.09	4.39

7. CONCLUSION

The high strain rate impulsive snow consolidation was performed for strain rate $\acute{\varepsilon} \approx 5.00 \cdot 10^{-2} - 10^{-1}$ s^{-1}. Then the coefficient of lateral earth pressure at rest K_0 was evaluated. And it was found that following,

1. It was re-realized that the snow consolidation needs multiple point pressure measurement for safety design and usage of equipment.
2. Initial snow filling ration H/W was strongly affected on K_0, and K_0 = 3.51 for p_{z_max} = 1.0 MPa, v = 50

mm·min^{-1}. And the set maximum axial formation pressure p_{z_max} did not affect K_0.

3. The lateral pressure was strongly affected by formation velocity on the snow consolidation formation. The maximum K_0 was K_0 = 4.39 for H/W = 1.1, p_{z_max} = 0.5 MPa.

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PURCHASE OF CHROMEBOOKS TO FACILITATE THE CREATION OF A REMOTE LEARNING ENVIRONMENT AND USE IN THE CLASSROOM

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Abstract

Google Classroom-based remote classes were conducted from May 2020 to August 2020 in order to continue education in the midst of the corona pandemic. The results of three questionnaires revealed that the reason why students felt difficulty was due to the inconsistent style of class materials and the quantity of assignments. We were able to improve classes by unifying the style of class materials and controlling the number of assignments. Face-to-face classes were resumed after September 2020, but the basic policy for classes was to prepare class materials in a distance learning format and to continue using Google Classroom. 180 Chromebooks were distributed by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) in 2020. They were purchased with the budget from the *Securing Learning Opportunities through the Feasibility Study* and loaned to all first-year students (about 160 students) and several faculty members in 2021. This provided an environment where students could easily view class materials and PC exercises in regular classrooms. The amount of time spent on PC exercises in class has tripled over the previous years. The percentage of students who achieved the target in touch-typing ability increased from 71.8% to 93.6%, an increase of more than 20%. The percentage of students who reached a higher level of proficiency increased significantly from 31.2% to 55.0%.The school's policy of transitioning to BYOD is about to be realized, as the school has been able to greatly reduce the amount of time spent in the school's PC room by lending Chromebooks..

Keywords: *Distance learning, on-demand remote leaning, Education without PC rooms, Chromebook, G Suite, Google Classroom.*

Introduction

The corona pandemic has increased the use of remote classes and the need to purchase equipment and software for this purpose. In our school, the following schedule has been used to incorporate remote classes and ICT equipment.

- April 2020: Students are not allowed to attend school. Google Workspace is selected as the LMS tool for remote classes; information on how to use Google Classroom and other tools and how to conduct remote classes using them is shared within the school. Remote classes begin in some classes.
- May: Almost all classes begin using Google Classroom as the primary remote learning tool.
- End of May: The first remote class survey is conducted among students, parents, and faculty.
- End of June : The results of the survey are announced on campus. Weaknesses of our school's remote learning system and ways to improve it are shared.
- August: Second survey of students on distance learning. Confirmation of class improvement status.
- End of August : All students come to school to start face-to-face classes, and Google Classroom is actively used to distribute class materials. For students who cannot come to school, high-flex classes using Google Meet are started.
- September 2021 : The 3rd survey on remote learning is conducted for students.
- April 2021: 180 Chromebooks were purchased and loaned to all first-year students.
- April 2022: 180 additional Chromebooks were purchased and loaned to all first-year students.

The 180 Chromebooks purchased in FY2021 were purchased by obtaining a budget from the Ministry of Education, Culture, Sports, Science and Technology. The same budget was also used to purchase G Suite as educational software. In this paper, we describe the remote classes conducted in FY2020 and its improvement based on the results of a questionnaire survey. After that, an overview of the education using Chromebooks conducted in FY2021 will be presented, and the educational effects will be examined by comparing the actual practice time, PC room usage time, and the achievement level of touch typing between FY2018 and FY2021.

Result and Discussion

2020: Start and Improvement of Distance Learning

In April 2020, there were no faculty members with experience using Google Classroom for classes. Information on how to use the necessary software and know-how on class management was collected and shared at a university-wide workshop, and a university-wide remote class was launched in May. Students took classes at home using PCs and smartphones. After one month of classes, the first survey was conducted. The good points of the distance class obtained from the students were as follows.

1. I can study at own pace.
2. I can relax, feel safe, and concentrate.
3. I can manage my own learning.
4. I can view the class content as many times as I want.

Distance learning has some advantages over conventional face-to-face classes in terms of student initiative.

The disadvantages of distance learning were as follows.
Insufficient content and explanations in the class materials.

1. Materials are not easy to read.
2. The quantity of assignments is too large, and the format for submitting assignments is difficult to understand.
3. It is difficult to ask detailed questions.
4. It is difficult to ask detailed questions, or the teacher's answers are too slow.
5. The speed of the communication line at home is slow.
6. Difficulty in viewing and operating materials because I only have a smart phone.
7. Inability to manage study by myself, inability to concentrate.
8. I feel stress. My eyes get tired.

As study management was listed as both a good and a bad point, the evaluation of the remote class varied according to the individual personalities and feelings of the students. Based on the results of the questionnaire analysis, the basic policy was to standardize the format of class materials and the method of submitting assignments in all classes and not to make the quantity of assignments too large in order to reduce student difficulties.

Comparison of class materials for several classes revealed that there were various patterns, such as a pattern in which only important terms and diagrams were displayed as images, and a pattern in which the teacher wrote additional explanatory text by pointing to pages in the textbook. The basic style of the class materials was to provide screen materials summarizing important points and diagrams (what would be written on the blackboard in a face-to-face class) and explanatory text by the teacher in the form of PDF files.

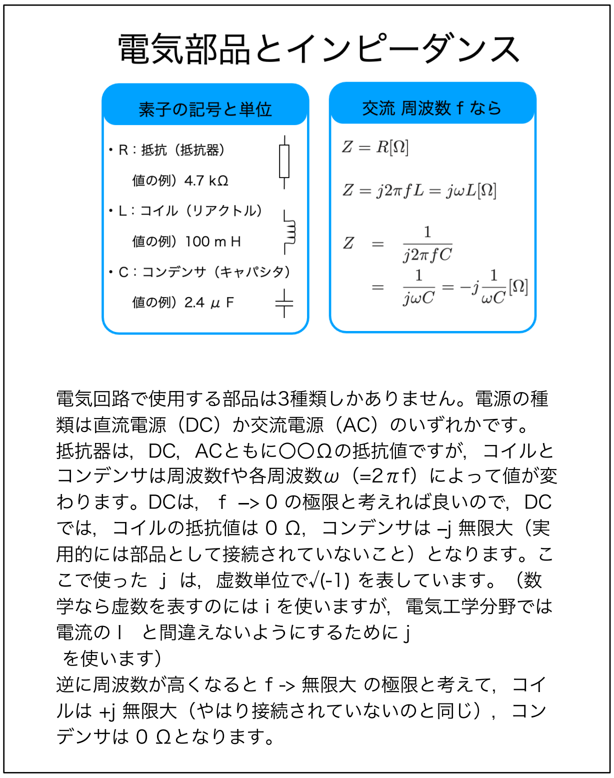

Figure 1: Example of basic style of class materials

In August, a survey was conducted with the objective of identifying improvements in the classes. The results showed that 85% of all students responded that the class had improved compared to the May survey. 85% of all students answered that the class had improved. Students were asked to choose multiple answers from a list of 10 options regarding improvements. The most common responses were as follows.

1. The materials and assignments are less burdensome in terms of content and quantity. (31%)
2. The text of the materials is easier to read. (29%)
3. Materials and assignments are more organized and easier to find. (26%)
4. The method of submitting assignments has been simplified and made easier. (25%)
5. The materials and assignments correspond to each other and are easy to understand. (23%)
6. The explanatory material and examples made it easier to understand. (20%)

It was found that the same format of class materials in principle and the standardization of the submission method by saving the amount of assignments worked effectively.

In September, the same face-to-face classes as before resumed, so we conducted the third questionnaire survey to compare remote classes and face-to-face classes.

When asked which class format they thought was more effective for learning, 19% of the students responded "distance learning" and 59% responded "face-to-face learning. Although some of the advantages of distance learning were mentioned, such as the ability to access class materials at any time, most of the students seemed to be pleased to be able to take classes while seeing the familiar faces of the teachers they had known in their lives.

Around August, when the remote class was about to end, there were a number of problems with assignment submissions. When asked about problems in submitting assignments, 65% of the students answered that there were no problems and 35% answered that there were some problems. The causes of the problems included problems with the network environment on the student side and communication problems on the Google side due to a sudden increase in traffic.

The school decided to actively use Google Classroom to provide class materials and submit assignments after September 2020, because the system for creating materials and submitting assignments for remote classes can also be used for face-to-face classes, and it is not clear when the COVID19 pandemic will end.

2021: Improvement of Learning Environment and Verification of Educational Effectiveness

In April 2021, 180 Chromebooks were loaned to all first-year students (160 students) and teachers in charge of classes. The purpose of this project was to improve the environment for students who do not have their own personal computers, and to improve the overcrowded PC room usage schedule due to the increase in classes using digital content such as Google Classroom.

Students received a lecture on how to use the Chromebooks in their "Information Processing" class and then learned the basics of information technology using the Chromebooks. The Chromebooks were also used in other classes for research and English study. In the past, classes using information equipment could only be held in the PC room, but now that each student has a Chromebook, those classes can be held in a regular classroom, so their time in the PC room has almost disappeared. The skills they acquired will be evaluated by touch typing scores, and the effectiveness of the classes will be examined by evaluating the results of quizzes and periodic examinations, as well as class evaluation questionnaires by the students.

Changes in the class "Information Processing

This section describes the changes in the content of the "Information Processing" class before (FY 2018) and after (FY 2021) the introduction of Chromebooks. Before the introduction of Chromebooks, the course focused on classroom lectures, and students were not required to actually use PCs and application software. Before the introduction of Chromebooks, the course focused on classroom lectures, with only three sessions of Excel operation exercises out of a total of 30 classes in which students actually used PCs and application software. On the other hand, after the introduction of Chromebooks, the students practiced 10 times how to use Chromebooks and how to use Google Docs, spreadsheets, and slides. Class materials were viewed on the Chromebooks each time. In addition, collaborative exercises using Google applications were conducted in the last two sessions.

Comparison of Typing Levels

In Information Processing, touch typing training was conducted with the goal of students achieving a certain level of proficiency over the course of the year. The results will be compared between FY 2018, before the introduction of Chromebooks, and FY 2021, after the introduction of Chromebooks. The amount of time spent in class explaining and practicing touch typing was similar in FY 2018 and FY 2021.

In both years, touch typing training was conducted using e-typing, a web browser-based typing practice and level assessment website.

Short sentences such as idiomatic phrases are displayed on the screen in Japanese and Roman characters, and the user types the sentences. About 10 sentences selected to be about 400 typed characters are randomly displayed, and the time required for input, the number of typed characters, the number of incorrect input, the number of typed characters per minute (CPM), and the accuracy rate are measured and a score is calculated. The scores are divided into levels according to the range of scores, from E with the lowest score to E, D, C, B, A, and S with the highest scores in that order. The table below shows the score ranges for the levels and examples of CPMs and accuracy rates for students who achieved those scores.

Table 1: Level Classification (left side) and Examples of Student Trials (right side)

Level	Score	CPM	Accuracy %
S	260 over	288	97.3
A	209 – 259	256	93.7
B	158 - 258	208	97.5
C	107 – 157	147	98.7

The achievement goal that the course instructor required of the students was Level C or above. Although the formula for calculating the score has not been disclosed, it appears from the student trial results that the score is generally determined by the product of CPM and accuracy rate, so that a score of 107, the lowest score to be judged as Level C, corresponds to an accuracy rate of 100% for 107 characters per minute or more than 95% for 113 characters per minute. McPherson (1955) reported that in an effort to improve typing ability in a public high school in the U.S., the typing speed of high school students after four weeks of training was 26.9 words per minute, which is in the middle of the score range for Level C in Table 1. The

achievement goal we set for our students is at the same level as that of U.S. public high school students.

Table 2 and Figure 2 show the number of students who reached each typing level; the results are for the 2018 and 2021 academic years, with the 2018 results using PCs in the PC lab and the 2021 results using Chromebooks.

Table 2 Number of students who reached each level

Level	E	D	C	B	A	S
2018	2	46	69	33	14	6
2021	0	11	66	55	27	12

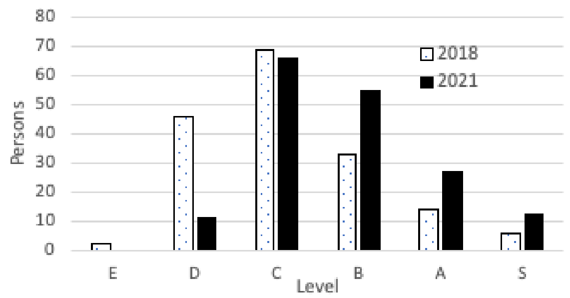

Figure 2 Number of students who achieved level

Figure 2 shows that the number of students who achieved level C or higher increased by more than 20%, from 122 (71.8%) in FY 2018 to 160 (93.6%) in FY 2021. Focusing on higher levels, the number of students at Level B or higher increased from 53 (31.2%) in FY 2018 to 94 (55.0%) in FY 2021, indicating that the majority of students reached a higher level than the setting.

Since the amount of in-class typing training was similar between FY 2018 and FY 2021, this difference may be attributed to the fact that students became more familiar with the keyboard by spending more time with it due to the loan of Chromebooks to individuals and to the fact that they practiced at home and other places outside of class time.

English Education

Prior to the introduction of Chromebooks in FY2021, students used online tools for spaced vocabulary study, listening and extensive reading assessment and portfolio generation. Students primarily did this work using computers in the crowded computer labs during regular class time or after school when the computer labs were open. Other skills, including intensive reading, writing, critical thinking, grammar, and speaking were taught using textbooks and traditional classroom techniques and tasks.

The onset of the pandemic presented several problems. Initially many students did not have access to a computer or the Internet. Access to the library extensive reading books was severely restricted. Since in-person classes were not being held, teaching skills requiring classroom instruction was not possible.

After introduction of Chromebooks during the onset of the pandemic, students no longer needed to use the computer labs and were freed to do their studies in the regular classrooms or at home. When they could not attend school, they were able to keep in touch with the Chromebooks with G-Suite. Google Classroom and Google Forms provides a reliable, unified platform with flexible tools for the aspects of English teaching that were previously taught only in the classroom. Google Classroom also provides a central porthole for all computer-based learning.

One measurable aspect of student achievement is vocabulary word acquisition. After Chromebook distribution FY2021 first year students achieved a similar amount of vocabulary as FY2020 first year students. FY2021 students had several months of distance learning whereas FY2020 students had supervised classroom study in the computer lab.

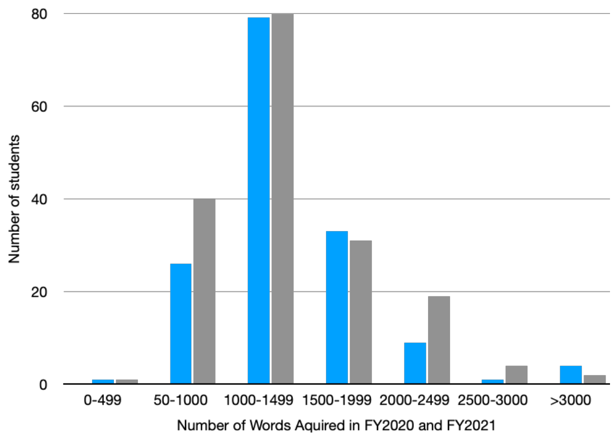

Figure 3 Number of first year students and number of words acquired in one academic year

Impact of Chromebooks on BYOD Policy

Chromebooks were loaned to all first grade students in FY2021 and continued to be loaned to them in FY2022 when they entered the second grade; an additional 180 new Chromebooks were purchased in FY2022 and loaned to all first grade students. As a result, in FY2022, all students in the first and second grades had one Chromebook each.

The school plans to start a "Bring Your Own Device" (BYOD) system in which all students in the third grade will bring their own information devices to class from the 2023 school year. Students who will be in the second grade in 2022 must return their loaned Chromebooks at the end of 2022, since these Chromebooks will be loaned to the new first grade students. Therefore, students currently in the second year will need to have their own PCs, etc. by the start of the 2023 academic year. Table 3 shows the percentage of students who have their own PCs and other equipment. Since 53% of the current second-year students own a PC, we believe that most second-year

students will be able to prepare their own PCs by the start of the 2023 academic year.

Table 3: Percentage of Students Owning PCs (as of May 2022)

Grade in School	1	2	3	4	5
Possession Rate %	35	53	64	81	89

In 2025, all students from the third to the fifth grades will be BYOD, but since Chromebooks will be loaned to students in the first and second grades, 100% of the students can achieve this goal, and since 60% to 90% of students in the third grade and above still own PCs, etc., the transition to BYOD for all grades is Therefore, we can expect the completion of the system to shift to BYOD in all grades.

Results of Questionnaire Survey for BYOD Transition

There are approximately 800 students from the first to the fifth grades at the school, taking a variety of classes, of which at least a part is using information equipment for approximately 40 hours per week. For this reason, there are three PC rooms on campus: two with 50 PCs and one with 70 PCs. Of the total of 170 PCs, 70 were purchased with the school budget, while 100 are leased equipment on multi-year contracts. These PCs use the same Active Directory service to provide personal authentication and desktop environment for students. The annual cost of maintaining this learning environment is several million yen, and once the BYOD system is completed, the need for a PC room will be eliminated and the budget for maintaining the PC room and equipment will be reduced. However, if special software, such as 3D CAD software, is required for classes, the equipment that runs it must be maintained. In May 2022, we conducted a survey on PC room use among faculty members. The number of responding courses was 90, of which 21 courses used PC rooms and 13 courses used Chromebooks.

In the first and second grades, the PC room was used only partially because students often used the loaned Chromebooks, and this was limited to the use of software that does not run on Chromebooks.

In most cases, students in the third grade and above use the PC room, but nearly 50% of the classes that use PCs use students' private devices, making the system a combination of PCs in the PC room and BYOD. The question was asked, "Can the current classes be converted to a BYOD system?" In the third and fourth grades, 71% of the respondents answered "yes," while 29% of the respondents in the fifth grade answered "no." The reasons given for not being able to migrate included the following: "I can't migrate to a BYOD system. Reasons given for not being able to make the transition included the following.

1. Migration is not possible unless all students bring their own PCs instead of tablets, etc.
2. Because a specific unified usage is required, such as installing a virtual OS.
3. Because certain software licensed by the school cannot be installed on privately-owned PCs.

Both 1 and 2 are matters that depend on a common educational material platform, and 3 is a matter that depends on the software license agreement. To satisfy these requirements, we believe it is necessary to leave enough PCs for each class (40 to 50 students) on campus.

Conclusions

The school conducted remote classes based on Google Classroom from May to August 2020. Based on the results of several questionnaire surveys, we determined that the reasons for students' difficulties were the variety of formats for class materials and assignment submission methods and the large amount of assignments, and we were able to improve the class by standardizing class materials and assignment submission methods and reducing the amount of assignments. The basic policy of the class was to prepare remote class materials and to continue to use Google Classroom.

New Chromebooks were purchased and loaned to students to provide an environment in which students could easily view class materials, and PC practice was realized in the regular classroom. The percentage of students who reached the target of touch typing ability increased more than 20% from 71.8% to 93.6%. The percentage of students who reached a higher level of proficiency increased significantly from 31.2% to 55.0%, and the introduction of Chromebooks greatly reduced the time spent in the school PC room, making the school's policy of transitioning to BYOD a reality.

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How do you "The Gleaners" of Radio Wave ?
-Practical Training of Energy Harvesting for Young Engineers-

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Abstract

A one of the Japanese societies, the contest committee in the institute of electronics, information and communication engineers (IEICE) technical committee on wireless power transfer (WPT), has planned a technical event for young engineers and students. This event was held on March 20, 2022 and is consisted of 2 special talks on the morning and an experiment on the afternoon. Targeted young engineers of the event are, for example, new employees, students in a "KOSEN", and students in not assigned to a laboratory of a university. Moreover, students in a high school, a junior high school, and students in an elementary school are also targeted. In fact, the youngest participant was 10 years old. In this event, the most important theme is "easy & enjoy". The participants learned about an energy harvesting technology through an easy experiment. The participants used two toy transceivers and harvested a radio wave of the transceivers. The committee call the harvesting to "The Gleaners" of Radio Wave". The toy transceiver can output 10 mW signal at 422 MHz-band. So, the participants firstly made an antenna for receiving the radio wave by using an aluminum foil. A length of a dipole antenna for receiving of the radio wave is about 350 mm - 360 mm. The radio wave received by the antenna is rectified and a DC power can be obtained. By using the obtained DC power, the participants turned on a LED and charged a capacitor. The participants learn about a fundamental knowledge of an antenna technology and WPT technology. The participants consider an appropriate form of the antenna, an optimum feeding position of the transceiver, etc. through the experiment. Some tools and some electrical elements are necessary in the experiment. For this event, our committee was given a financial support by IEICE. Thanks to the financial support, all of the tools and the elements, two transceivers, some LEDs (red, yellow, green, amber, blue), two capacitors (22 mF), a rim of aluminum foil, some lead wires with clips, batteries for the transceivers, and a masking tape for sticking the antenna, could be distributed to the participants freely. Our committee expect that all of the participants felt free to learn and enjoyed an energy harvesting technology.

Keywords: *young engineers, practical training, wireless power transfer, energy harvesting, IEICE*

Introduction

Recently, a one of the cutting-edge technologies, wireless power transfer (WPT) technology[1] including energy harvesting, has been actively studied[2] and applied with various applications[3]. The institute of electronics, information and communication engineers (IEICE) technical committee on WPT is active for development of WPT technology[4]. Not only our committee but also all other societies are looking forward to success of young engineers and students.

For research and development of WPT technology, advanced knowledge of high-frequency electromagnetic wave is required. So, the youngers feel hesitant to experience WPT technology. For overcoming this issue, our committee has held some WPT technical events. For example, a technical lecture[5] is held for young engineers on November 27, 2020. In addition, we has held a technical event for youngers on March 20, 2022. The title of the event is “How do you “The Gleaners” on Radio Wave ?”, and the event was online style. The most important theme in this event is “easy & enjoy”. In this

paper, the event is discussed. Our committee expect that this event provides triggers that young students will be interested in WPT technology and they would like to be WPT engineer in the future.

Overview of Our WPT Event

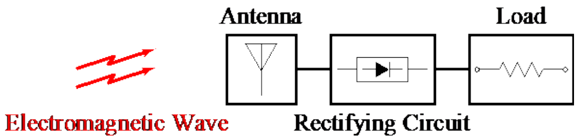
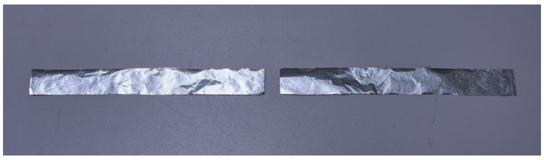


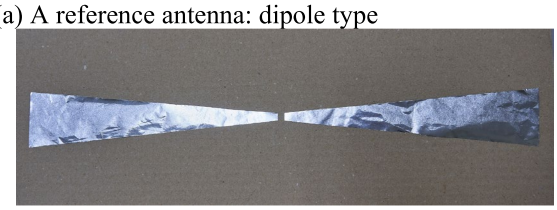
Figure 1. A fundamental energy harvesting system.

An energy harvesting is a technology that some inherent energy sources, for example, wind, heat, vibration, and electromagnetic wave, are harvested and are re-used as power. The energy harvesting used electromagnetic wave in UHF-band was taken up in our event. A fundamental energy harvesting system is shown in Figure 1. Electromagnetic wave is received by an antenna. Received electromagnetic wave is treated as radio frequency (RF) power, and it is rectified by a rectifying circuit, then DC power is obtained. Obtained DC power is supplied to a load, for example, LED, low power sensor, etc. For an experiment of the energy harvesting, all of participants of the event have been distributed some tools: two toy transceivers as a source of electromagnetic wave, an aluminum foil and a masking tape for fabricating of a receiving antenna, two diodes for rectifying, some LEDs for a load, two electric double-layer capacitors for some load applications, four lead wire lines. These tools were given to the participants for free. The cost per person is about 7,000 JPY. The distribution was supported by financial supports from IEICE, UL Japan, Inc., Power Wave Co., Ltd., and Fujiwaves CO., LTD.

A specified low power transceiver shown in Figure 2 was used as a source of electromagnetic wave. Maximum output power of a specified low-power radio equipment is 10 mW. This power is a legal requirement. The transceiver is also used for a children’s toy, so it is low cost and is safety for the experiment. Generally, some advanced knowledge and dedicated machines are necessary for designing and fabricating of an antenna and a rectifying circuit in UHF-band. However, in this event, “easy” is the most important theme. Therefore, two technical lectures were provided to the participants of the event in advance of the experience. In the lectures, some fundamental knowledge and skills needed for the experience were lectured. The participants fabricated a receiving antenna by using an aluminum foil. Two types of the antenna are shown in Figure 3 (a), (b). (a) is well known as a dipole antenna, and (b) is known as a bow-tie antenna. Input impedances of these antennas are different each other. The participants can select not only the two types but also other several types of the antenna according to a load connected to the antenna. In the experiment, harvested power is low level, so a diode for


Figure 2. An energy source: a specified low-power radio equipment.


(a) A reference antenna: dipole type


(b) A reference antenna: bow-tie type
Figure 3. Two types of reference antennas for receiving of the electromagnetic wave.

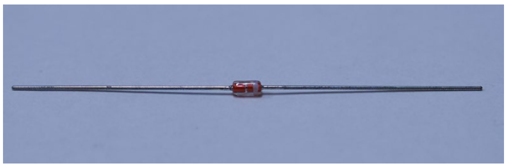
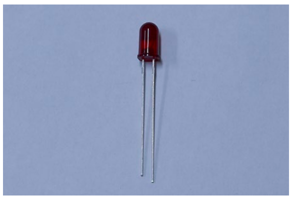
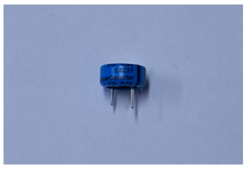
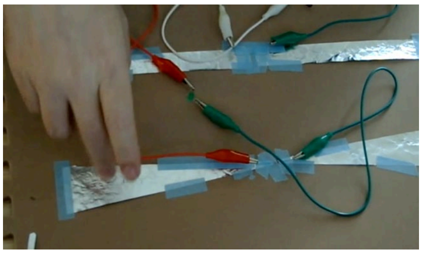


Figure 4. A diode for rectifying (1SS-106)

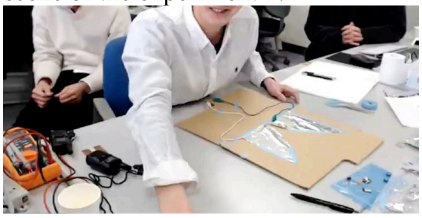

(a) A sample load: red LED


(b) A sample battery: electric double-layer capacitor (22 mF)
Figure 5. A load for the energy harvesting system.

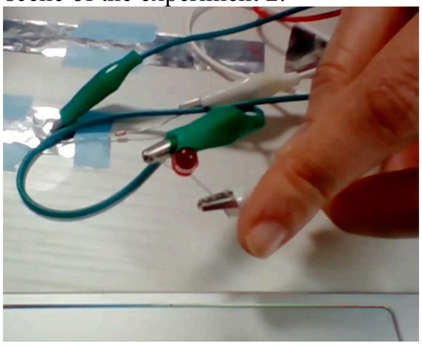
rectifying of which forward voltage is low is desired. Therefore, a Schottky barrier diode is used. The diode is shown in Figure 4. A model of the diode is 1SS-106 fabricated by Renesas Electronics Corporation. The diode is pasted to center of a receiving antenna by a masking tape. One or some LEDs or electric double-layer capacitors are connected to the receiving antenna as a load (Figure 5). Five types of LEDs (red, yellow, green,



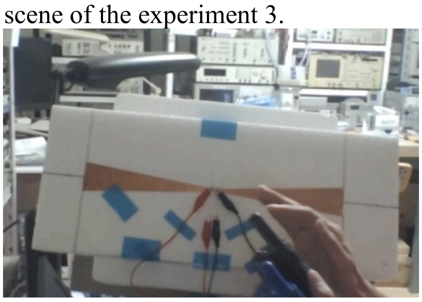
(a) The scene of the experiment 1.



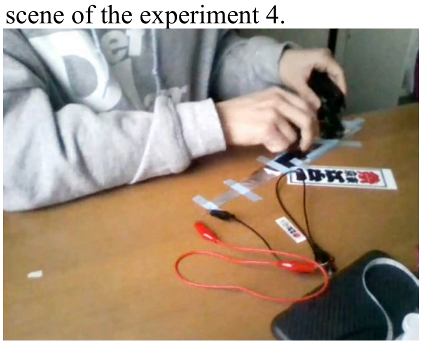
(b) The scene of the experiment 2.



(c) The scene of the experiment 3.



(d) The scene of the experiment 4.



(e) The scene of the experiment 5.

Figure 6. The screenshots of the event.

amber, and blue) were given to the participants. Each LED has different forward voltages, so the participants can select the appropriate LED, and the capacitor can be used as a simplified battery.

Results of the Event

In this event, the number of participating groups was 50 groups, and the number of groups including the audiences was over 68. The age of the participants was from 10 years old to over 60 years old. Over 90 % of the participants could turn on the LED by using the bow-tie type reference antenna. Affiliation of each participant is the primary school, the colleges, the university, the company, retiree, etc. Some of the participants joined the event with their family and they enjoyed the event together. After the event, parts of the participants re-considered and reported some more appropriate antenna form for the harvesting. Figure 6 shows some screenshots of the event.

Conclusions

In this event, there were many participants although the event held on Sunday. The experiment tools were free, and the contents of the event was fundamental, easy and enjoyable. We consider that these are the reason. In this event, Zoom application was used. All of the participants got used to using the online tools, so the progress of the event was very smooth.

Acknowledgements

The authors are grateful to Professor Y. Fujino (Tokai University, Japan) for the technical special supports, IEICE, UL Japan, Inc., Power Wave Co., Ltd., and Fujiwaves CO., LTD. for the finalcial supports.

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Teaching Microwave Engineering Using Multiphysics Simulations

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Abstract

Courses/classes using simulation and learning simulation programs have been conducted at universities and national institutes of technology (KOSENs) to enhance the understanding of physics. In semiconductor and electronic component industries, problems are becoming increasingly complex in not only research and development but also production plants. For example, the smaller the component, the higher the current density, and the greater the heat dissipation issues to be considered. Engineers, regardless of their fields of expertise, are expected to understand and solve problems daily. With rapid advancements in information and communications technology, physical phenomena that was previously significantly time consuming can now be simulated on a personal computer. A person can perform Multiphysics simulations as a calculator. Therefore, instead of teaching mainly simulations and programs, we focused on training students to operate Multiphysics simulations and understand their physical laws to model complex physical phenomena without contradicting physics principles. In the first semester, I lectured and conducted exercises on topics, such as the derivation of general solutions for radio waves from Maxwell's equations, antennas, transmission lines, resonators, Smith charts, and S-parameters on microwave engineering for a batch of advanced course (equivalent to third-year students in universities) at Okinawa KOSEN from 2016 to 2020. Next, in the second semester, I created an environment where students could run Multiphysics simulations on the commercially available finite element method on their personal computers. In addition, I lectured students using Multiphysics simulations. During this lecture, I conducted exercises on simple structural mechanics, laminar flow problems, which are simple fluid dynamics, and heat transfer problems, such as heat generated when electricity is applied, and the electromagnetic field distribution in antennas and cavity resonators. Students taking the course learned simulations with built-in three-dimensional computer-aided designs, modelling methods based on differential equations, and microwave engineering described by Maxwell's equations.

Keywords: *Multiphysics simulation, Maxwell's equations, microwave engineering, electromagnetic wave, modelling method*

Introduction

Problems in both R&D and production plants, of the semiconductor and electronic component industries, are becoming increasingly complex. For example, the smaller the component, the greater the current density. Therefore, it is necessary to consider the issues related to heat dissipation and effects of signal line crosstalk caused by fine wiring and higher speeds. Engineers are required to understand and solve problems on a daily basis, regardless of their field of expertise. In addition, courses/classes using simulation and learning simulation programs have been conducted at universities and technical colleges to teach physics [1-3]. However, although the computational speed of PCs has improved, programming for the subjects of electromagnetics and microwave engineering has become complicated, and education is likely to be include programming. Therefore, a commercial Multiphysics simulation was introduced to help students learn the physical laws of electromagnetics and microwave engineering through the modelling and simulation of various problems in microwave engineering.

Materials and/or Methods

In the first semester, I lectured and conducted exercises on topics, such as the derivation of general solutions for radio waves from Maxwell's equations, antennas, transmission lines, resonators, Smith charts, and S-parameters on microwave engineering for advanced course students (equivalent to third-year students in universities) at Okinawa KOSEN from 2016 to 2020. For the microwave engineering lecture, Microwave Engineering by D. M. Pozar, which is a good book on microwave engineering for the first semester of major science course students of Okinawa National College of Technology (equivalent to third-year students in universities) who have mastered basic electromagnetics, was adopted as the subject [4]. Because the volume was considerable for third-year university students, we decided to use excerpts from this book. I lectured and conducted exercises on topics, such

as the derivation of general solutions for radio waves from Maxwell's equations, antennas and transmission lines, resonators, Smith charts, and S-parameters. The students were taught to derive plane waves and their general solutions, Snell's law, and solutions for TE/TM modes from Maxwell's equations described in the differential system while they themselves developed the equations line by line. Figures 1 and 2 show the equation for electromagnetic wave loss and an example of Snell's equation, respectively. The students were also taught the basics of vector operations, such as inner and outer products, three-dimensional space, frequency domain, time domain, and waves, using own materials. More importantly, they were asked to think about the development of equations one at a time, without using a computer. In a simulation, one must build a model, set boundary values, and seek the best solution. The purpose of this study was to explain this procedure.

$$\nabla \cdot \bar{D} = \nabla \cdot \varepsilon \bar{E} = 0$$
$$\nabla \cdot \bar{B} = \nabla \cdot \mu \bar{H} = 0$$
$$\nabla \times \bar{E} = -\frac{\partial \bar{B}}{\partial t} = -j\omega\mu\bar{H}$$
$$\nabla \times \bar{H} = \frac{\partial \bar{D}}{\partial t} + \bar{J} = j\omega\varepsilon\bar{E}$$
$$\nabla \times \nabla \times \bar{E} = -j\omega\mu\nabla \times \bar{H}$$
$$\nabla^2 \bar{E} + \omega^2 \mu\varepsilon \bar{E} = 0$$
$$\nabla^2 \bar{H} + \omega^2 \mu\varepsilon \bar{H} = 0$$

$$\frac{\partial^2 E_x}{\partial z^2} + k^2 E_x = 0$$
$$E_x(z) = E^+ e^{-jkz} + E^- e^{+jkz}$$
$$\mathrm{Re}(\bar{E}) = \mathrm{Re}\left(E_x(z) \cdot e^{j\omega t}\right) = \mathrm{Re}\left(E^+ e^{-jkz+j\omega t} + E^- e^{+jkz+j\omega t}\right) = E^+ \cos(\omega t - kz) + E^- \cos(\omega t - kz)$$

Figure 1 Electric Plane wave derivation process

$$\bar{E_i} = E_0(\hat{x}\cos\theta_i - \hat{z}\sin\theta_i)e^{-jk_1(x\sin\theta_i + z\cos\theta_i)}$$
$$\bar{H_i} = \frac{1}{\eta_0}\hat{n}\times\bar{E} = \frac{E_0}{\eta_1}\hat{y}e^{-jk_1(x\sin\theta_i + z\cos\theta_i)}$$
$$k_1 = \omega\sqrt{\mu_0\varepsilon_1}, \qquad \eta_1 = \sqrt{\frac{\mu_0}{\varepsilon_1}}$$
$$\bar{E_r} = E_0\Gamma(\hat{x}\cos\theta_r + \hat{z}\sin\theta_r)e^{-jk_1(x\sin\theta_r - z\cos\theta_r)}$$
$$\bar{H_r} = \frac{-E_0\Gamma}{\eta_1}\hat{y}e^{-jk_1(x\sin\theta_r - z\cos\theta_r)}$$
$$\bar{E_t} = E_0T(\hat{x}\cos\theta_t - \hat{z}\sin\theta_t)e^{-jk_2(x\sin\theta_t - z\cos\theta_t)}$$
$$\bar{H_t} = \frac{E_0T}{\eta_2}\hat{y}e^{-jk_2(x\sin\theta_t + z\cos\theta_t)}$$

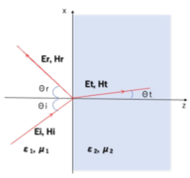


Figure 2 Explanation of Snell's Law

Next, in the second semester, the students could run Multiphysics simulations on the commercially available finite element method, on their personal computers. For the simulation lecture in the second semester, a commercially available class kit for the finite element method COMSOL Multiphysics was introduced, and each student was asked to run the simulation on individual PC [5]. The procedure for electromagnetic simulation consists of creating a model using 3D CAD, setting the boundary conditions, and obtaining the solution (eigenvalue solution, frequency response, and time dependence). Figure 3 shows the modelling of the applicator for the TE103 cavity using COMSOL Multiphysics. Impedance matching must also be considered for frequency characteristics. The procedure can be explained as follows: 1) As the first step of operation, exercises using COMSOL simulator were conducted on simple structural mechanics (Figure 4), laminar flow problems, which are simple fluid dynamics, and heat transfer problems, such as the heat generated when electricity is applied. 2) The boundary problems and eigenvalue solutions were explained, constructing

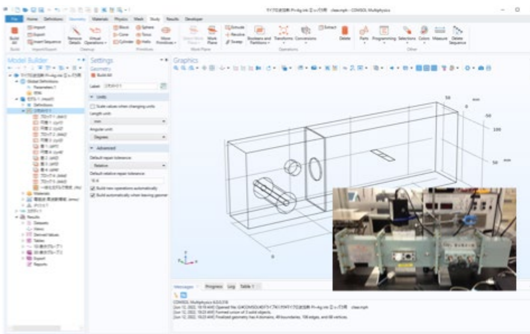


Figure 3 Modeling with COMSOL Multiphysics

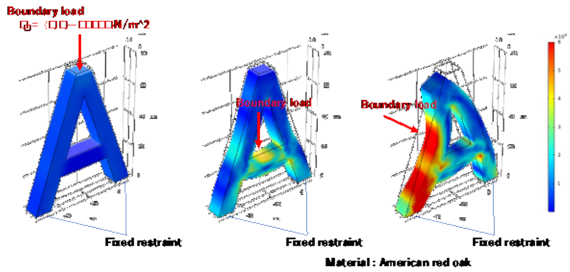
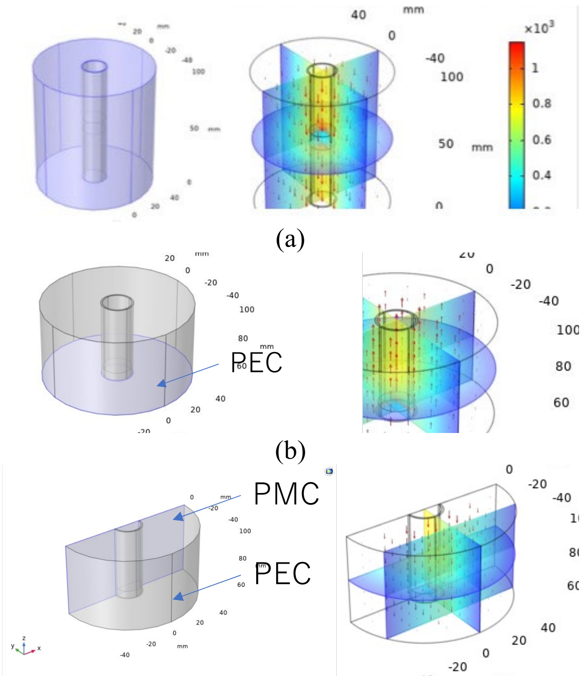


Figure 4 Load calculation results for structures



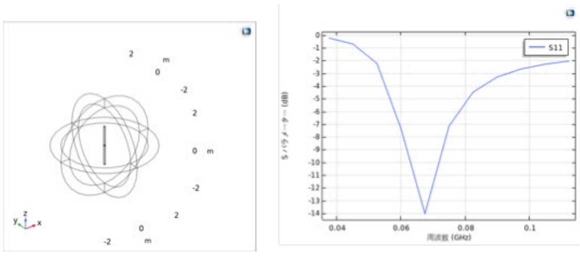
(a)

(b)

(c)

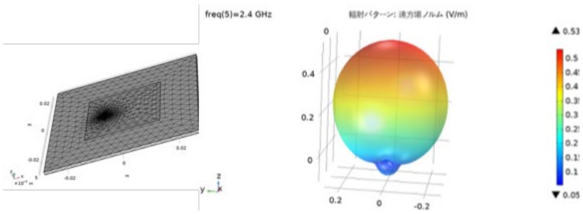
Figure 4 Eigenvalue calculations and results for cylindrical cavity resonators (a) full model (b) half model, (c) quarter model using PEC and PMC.

1/2 and 1/4 models for cylindrical resonators and finding the same solutions using the perfect electric conductor (PEC) and perfect magnetic conductor (PMC) (Figure 4), 3) Near-field electro-magnetic simulations and S-parameters of the dipole and patch antennas were obtained by EM simulation. 4) Multiphysics model, including electromagnetic field (frequency response) and heat transfer (time dependence), of microwave heating by a cylindrical resonator was used. The EM simulation is calculated in the frequency domain, and then the HT simulation proceeds with the transition calculation.



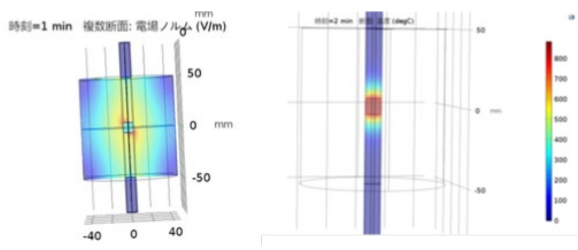
(a) (b)

Figure 5 EM Simulation of the dipole antenna (a) Far Field EM modelling of the dipole antenna, (b) simulation result of S11 magnitude of it.



(a) (b)

Figure 6 EM Simulation of of the patch antenna (a) modelling of the patch antenna, (b) simulation result of S11 magnitude of it.



(a) (b)

Figure 7 EM & Heat Transfer Simulation result of the cylindrical cavity resonator with quartz tube and the sample (a) Electric field of the cylindrical cavity, (b) Temperature distribution of the sample with microwave heating

Results and Discussion

Electromagnetics has been studied in microwave engineering; its principles and laws are studied in the integral system of four MaxWell equations. In microwave engineering, the principles and laws of electromagnetism are understood further by deriving electromagnetic waves from the four MaxWell equations presented in the differential system. In a survey of students, many responded that their understanding deepened. Furthermore, in the simulation in the second semester, students will learn to derive solutions from differential equations and boundary conditions, which we believe will enable them to learn more systematically. Furthermore, we believe that additional experiments such as antenna measurements will help students further understand the evaluation of high-frequency waves, including high-frequency measurement devices such as S-parameters.

Conclusions

During these lectures, I conducted exercises on simple structural mechanics, laminar flow problems, which are simple fluid dynamics, and heat transfer problems, such as the heat generated when electricity is applied, and the electromagnetic field distribution in antennas and cavity resonators. Students taking the course learned simulations with built-in three-dimensional computer-aided designs, modelling methods based on differential equations, and microwave engineering described by Maxwell's equations.

Acknowledgements

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USING DIGITAL BADGES TO TRACK STUDENT PORTFOLIOS IN VOCATIONAL EDUCATION

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Abstract

In vocational education, digital badges can supplement a student's achievement by helping them connect their on-campus experiences to those outside of the classroom as internship attachments, encouraging them to think and apply the knowledge gained through learning to real-life situations. This article discusses the perceptions of participants in a digital badge pilot system developed to support vocational education with internship attachment to identify user experience satisfaction that is critical to the design of a digital badge initiative. The purpose of this exploratory case study was to understand how students, employers, and teachers perceived the use of a digital badge pilot system to track student portfolios for internship attachment. Data collection included an online survey of students, employers, and teachers after the launch of the pilot system. Results were satisfactory from all stakeholders who have used the pilot system which will also be used to further develop a successful digital badge initiative to customize the system to support the internship attachment scheme.

Keywords: *digital badges, digital credentials, blockchain, vocational education, internship attachment*

Introduction

Nowadays, when students go to job interviews, they have to show all the original certificates they receive to the interviewers. The first problem with paper certificates is that the certificate can be fraudulent. According to a 2015 New York Times article, there are 3,300 diploma mills selling degrees to anyone willing to pay, and more than 50,000 doctoral degrees are purchased from these mills every year (New York Times Editorial Board, 2015),. Second, the certificate cannot show the student's actual ability to work. Students may only have the basic knowledge, but they lack the ability and skills to work in the workplace. The third problem is that students can easily lose their certificates. Then, they need the school to reissue the certificates. Applying for a duplicate certificate can cause significant problems for students and is also time-consuming.

In order to address these issues, our research team has developed a way to provide students with a convenient and secure way to show their academic credentials, competition, and work experience. As a result, a digital badge (D-badge) system has been developed to record and summarize the certification that students achieve through education and competition. The main technology that will be used in the D-badge is blockchain, which allows participants with digital credentials to track transactions without centralized record keeping. Blockchain can provide an extra layer of security and students can retain control of their verifiable credentials (Hope, 2018).

Vocational and Professional Education and Training (VPET) enhances learners to acquire professional knowledge, apply practical skills and develop positive workplace attitudes (Lam & Luk, 2020). The Hong Kong Institute of Vocational Education (IVE), a member institution of the Vocational Training Council (VTC), offers full-time and part-time programmes covering a range of disciplines. To nurture future-ready and work-ready talents equipped with all-around competencies and attributes, IVE students have always been encouraged to participate in the industrial attachment (IA) and internship activities. The D-badge allows the student, to have a complete record of their internship experience. This can encourage students to participate in different industrial attachment activities that can broaden their overall exposure and interest. Vocational education has expanded to encompass internships and sandwich programmes like earn and learn programmes. The use of D-badges to track IVE student portfolios were evaluated in this study.

Several studies have suggested that a well-designed customized digital credential tool can motivate the learning experience and build up the digital accreditation system (Brauer, 2019; Liyanagunawardena, Scalzavara, & Williams, 2017; Motheeram, Botha, & Herselman,

2018; Yamada, Fushimi, Saitoh, Higuchi, & Okada, 2021).

The Digital open badge-driven learning process encourages students to assess their recent performance as well as their acquired skills and prior learning (Brauer, 2019). Open badges have grown in popularity in recent years and have become a standard feature of many learning management systems (Liyanagunawardena et al., 2017). In order to test the feasibility of an open badge system for an institution, a small-scale pilot system can be set up to encourage learning and introduce micro-certifications to increase the scope of learning recognition (Motheeram et al., 2018). Developing an open badge pilot system is the first step for an institution to customize digital badges for its special teaching and learning environments. The launch of a successful implementation and recognition of digital badges may take a long time to gain recognition. For example, the Open University of Japan introduced a digital badge as an electronic certificate of the completion of the informal education programmes after launching the pilot study for six years in MOOCs to gain public recognition (Yamada et al., 2021). Since VPET programmes offered by IVE are unique in their operation, a pilot launch of a D-badge system was conducted to investigate the feasibility and recognition of these D-badges by stakeholders.

The four major advantages of using digital badges to track student portfolios in vocational education are as follows:

(1) D-badge can display students' achievements. All completed courses, competitions and work experiences can be assigned to a D-badge and saved on the server. Then, students can easily summarize their education, activities, and work experience in a resume when they need to find a job or internship. Also, students do not need to print all the certificates for proof. Students can show all certificates in the app. The App not only summarizes the certificates but also shows the ability in detail. In addition, the D-badge can show what students have actually learned and achieved in the course and work experience in detail. Also, it enables students to define their lifelong learning pathways and personalizes education based on individual values and needs.

(2) D-badge can reduce certificate fraud and ensure high credibility. D-badge uses Blockchain technology which can provide an extra layer of security so that the digital certificate is highly secure. Moreover, the certificate is issued by the school and other companies have great confidence in the school because the D-badge cannot be faked. In addition, the D-badge is not like a paper certificate which is easy to fake. As D-badge fraud is not easy, it can effectively reduce certificate fraud and increase public acceptance. In September 2018, Northeastern University accepted badges offered by IBM to count toward college credit. It increases the credibility of the D-badges (Gamrat & Bixler, 2019).

(3) D-badge can increase transparency. All the certificates issued by a school will be recorded in the server database and show the public the number of certificates issued each year so that the public has great transparency to know how many certificates are issued by the same school. This can prevent the school from issuing certificates indiscriminately and increase public trust.

(4) D-badge can help the company to find the right talent easily. According to Leaser (2019), 48% of respondents believe the D-badge can help badge issuers identify verified talent. So, if a company wants to find the right talent, it has to find people through an employment agency every time it needs to recruit new employees. This recruitment exercise wastes a lot of company time and does not easily find sustainable talent, but companies can find the right talent using the D-badge system. Companies can also search for talent by particular skills and education level.

In order to track all student portfolios during the internship, a digital badge platform deployed in IVE to support VPET was evaluated, which is critical to the success of these earn and learn programmes.

Research Questions

The three research questions of this paper are:

RQ1: How would D-badge assist employers in locating qualified candidates?
RQ2: How would the D-badge benefit students' professional profiles?
RQ3: How will D-badge help VTC advance student careers and put newly acquired knowledge into practice?

Methods

A pilot D-badge system was implemented, followed by an online questionnaire survey to be collected from stakeholders who had used the pilot system. In June 2021, we implemented a pilot D-badge system by implementing the Open Badges released by the Mozilla Foundation to provide the Open Badge Infrastructure that supports a verified and evidence-based digital badge (IMS Global Learning Consortium, 2018). Open Badges are image files that contain metadata that contains more information about credentials. This data covers who granted the credential, what was required to obtain it, and evidence that the requirements were met. After receiving and accepting an Open Badge, the earner has complete choice over how, when, and to whom their credential is shown. We incorporated Open Badges into our design for a variety of reasons.

The pilot D-badge system was tested by our IA companies, students, and IA supervisors to provide input on the system's usefulness. The stakeholders conducted a survey to assess how D-badge can assist them in an educational setting involving IA, prolonged attachments, and so on.

The main core of the D-badge is shown in Figure 1. The student gets the D-badges after passing the examinations or participating in competitions or activities. The school will validate the identity of the candidate and the personal information of the student to ensure that the data is correct. Then, the online platform

will issue a D-badge token to the student. Students can redeem the D-badges using the token. The student can also share the token or profile with the company to prove their achievement. The company can verify the D-badge after opening the token or profile on the website or mobile app.

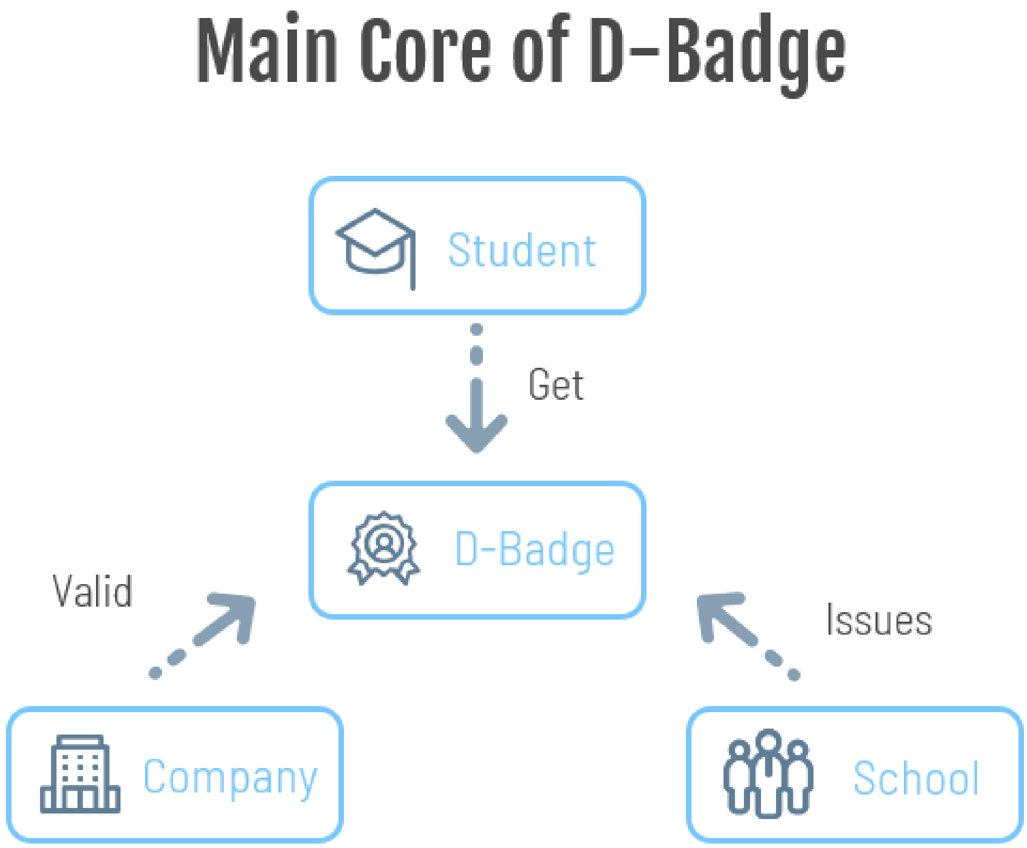

Figure 1. The Main Core of D-badge

The trust relationship between all stakeholders and the D-badge system is shown in Figure 2. The D-badge provides security, traceability, and encryption to the school using a trust relationship. In addition, the school's trust is ensured in the security of Block chain technology. Thus, the school trusts our high-security technology platform to protect all data and the D-badge will not be defrauded by others. The D-badge provides security, credential authenticity, and transparency to the company. In addition, the company trust is stored in the school and the company has great confidence in our platform. When the school issues credentials to students from our platform, students must have user accounts on our platform to receive and store the credentials. The D-badge provides security, convenience, verifiability, and privacy for students. Therefore, students can store their academic, competition and activity credentials in a secured platform. This can encourage students to use the D-badge to maintain their achievements in lifelong learning and development.

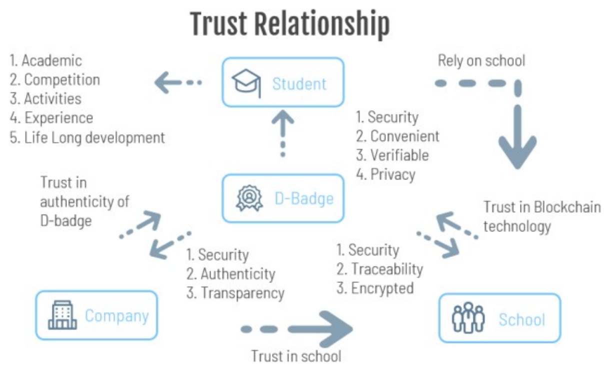

Figure 2. Trust Relationship

We customized the D-badge system to support the internship programs to revolve around the process of earning numerous digital credentials. Figure 3 shows the process of earning badges. The employer's experience with the students in this IA program can be separated into three phrases: (1) Observe, (2) Learn, and (3) Earn.

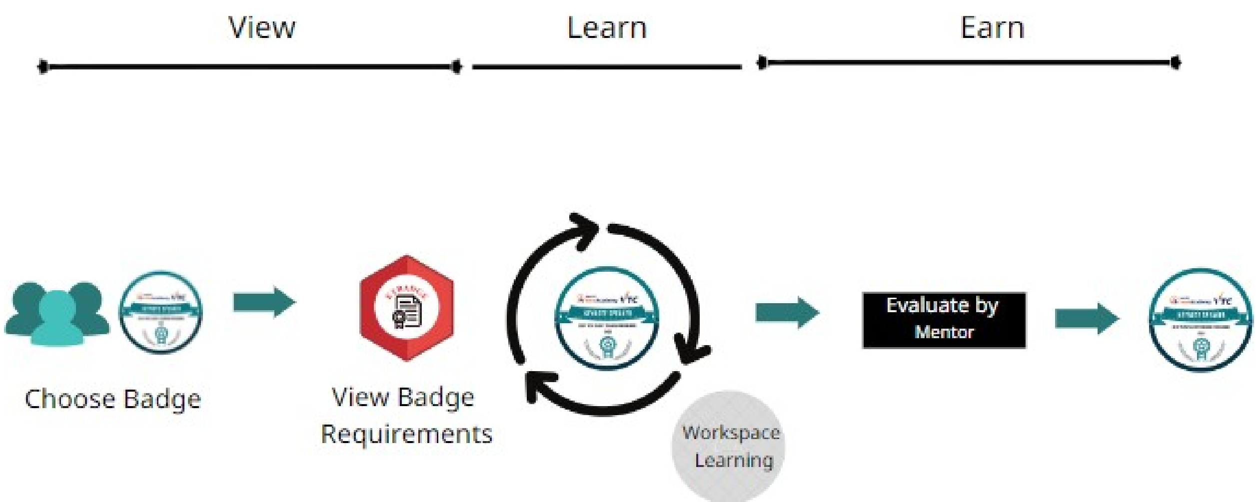

Figure 3. Process of earning badges

The three stages to earning badges are summarized as follows:

(1) View: The student chooses a badge that matches their internship criteria and reviews the associated requirements. The student can choose which IA badges they want to earn with the recommended internship attachments that are provided to help students understand the placement requirements.

(2) Learn: After a review of the badge requirements, the student may qualify for these requirements using any online resource.

(3) Earn: Every badge in our program necessitates the submission of qualifying proof for review by an employer or mentor. Mentors are chosen based on their competence level as determined by various examinations. Potential badge earners can submit evidence many times and tweak it depending on mentor input.

The online survey was conducted to answer each of the three research questions.

To address RQ1, the two measurement items in the online survey to be collected from employers or mentors are:

Q1A: How do you rank your satisfaction with using D-badge to recruit IA students?

Q1B: What are the advantages of using D-badge in verifying students' qualifications?

These preliminary results also set the context describing the industrial assessment settings under which D-badge were tested.

To address RQ2, the two measurement items in the online survey to be collected from students are:

Q2A: How do you rank your satisfaction with using D-badge to find IA jobs?

Q2B: Will you use D-badge to record your lifelong learning qualifications and work experience?

To address RQ3, the measurement item in the online survey to be collected from teachers is:

Q3A: How do you rank your satisfaction with using D-badge to help verify students' prior qualifications and profiles?

Results and Discussion

An online survey was conducted in May 2022 with 22 employers, 86 students, and 35 teachers who successfully completed the survey.

To answer RQ1: "How would D-badge assist employers in locating qualified candidates?", 79% of mentors trust the D-badge platform to review student skills, as the D-badge platform allows for detailed skill customization. Comments from the employer survey were positive stating that the skill alignment attribute can prove the portability of the student's talents and allow the employer to trust the student who has a specific skill.

To answer RQ2: "How would the D-badge benefit students' professional profiles?", the survey found a correlation between badges and engagement. Students who receive digital badges show higher engagement than students who do not. Of those receiving IA, 88.4% said they were more engaged with the digital badge system. According to student feedback, digital badges are verifiable digital documentation of competencies earned through Internship Attachment that can be published or endorsed on many professional platforms like LinkedIn for career progression.

To answer RQ3: "How will D-badge help VTC advance student careers and put newly acquired knowledge into practice?", 80% of teachers are satisfied with using D-badge to help verify students' prior qualifications and profiles.

Based on the successful launch of the pilot system and the satisfactory feedback from the survey, we recommend further customizing our D badge system to

make it an integral part of the IA programmes. An updated version of the D-badge system will now allow the student to have a complete record of their internship experience. This arrangement will encourage students to participate in different internship attachment activities that can broaden their overall exposure and interest. In addition, we recommend that students who have participated in IA also build a portfolio that includes a set of skills they have acquired through academic and industrial training. The constructive feedback from the survey comments also suggests that pilot testing of a new version of the D-badge system should be extended to other VPET programmes.

Conclusions

After a succces launch of the pilot D-badge system customised for IVE environment to track student portfolios in IA activities, we found that the credibility of D-badges depends on the security of D-badges and the number of students, schools and companies that join them. When the D-badges have higher security than a paper-based credential, D-badges can replace the paper-based credential. As D-badges can digitally display a student's achievements, they can attract students using it to summarize their learning and work experience. Compared to paper-based credentials, D-badges fully describe the experience and provide evidence of the student's claim.

The results of the employer survey show that employers can use D-badges to find suitable candidates with the right talent during interviews with satisfaction. D-badges also motivate students to acquire other knowledge, they help students to record their new achievements in lifelong learning after graduation.

The results of the student survey show that D-badges also motivate students to acquire further knowledge and support their lifelong learning after graduation. D-badge from students' perspectives brings value to IA by providing detailed recognition of the abilities they learn during IA, which can be added to their portfolio. Students can also choose the relevant IA to gain abilities that complement the talents in their portfolio. Employers can also choose more suitable IA students and graduates based on their skills by quickly selecting and matching students with the appropriate skills.

Overall, the survey results of the pilot D-badge system show that the D-badge system adds value to IA, VPET, and professional education by (1) allowing teachers (and/or students) to better track IA student progress, (2) allowing employers to easily verify student credentials and work experience, and (3) allowing teachers and employers to work together for tailored internship training for students to fill talent gaps in the industry

The limitation of the survey is that a small sample size also affects the reliability of the survey results as it can lead to bias for only those who have used the pilot D-badge system were invited to participate in the survey.

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A SELF-DIRECTED INTERNSHIP PROGRAMME FOR DESIGN STUDENTS

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Abstract

Self-directed learning initiatives have been instrumental in the transformation of the Internship Programme for a design diploma at Singapore Polytechnic (SP) since 2016. The integration of self-directed learning aims to teach students the process of taking ownership of their own internship learning and better prepare them for real-work challenges in this Volatility, Uncertainty, Complexity, and Ambiguity (VUCA) world. Mentorship element in the programme prompted internship companies and representatives to review the mode of working with interns for enhanced student learning. Different aspects of the self-directed learning elements and their application aid students to connect their curriculum learning with internship learning in context, motivate them beyond academic learning, exploring the prospect of acknowledging and overcoming uneven learning due to organizational situations. Scaffolding of the internship process guided students to take charge of their learning journey and moreover, develop reflective learning. The revised internship structure better navigates internship mentors for their role which involves deeper involvement and higher responsibility. Perceptions and learning experiences of student participants were collected and discussed for future improvement of the internship structure for a more effective learning experience for the student.

Keywords: *enhanced internship programme, self-directed learning, real-work challenges, motivation*

Introduction

In the design industry, real design problems are complex with multiple criteria, solutions, and goals. The domain is highly specific knowledge-based, subjective, and constantly require changes with the current trend and different context (Jonassen & Hung, 2008). In the endeavour to present an authentic learning environment for design-related diplomas students, it is common to use project-based approaches to anchor design curriculum learning to replicate industry projects demands and develop relevant real-world skills in learners (Savery & Duffy, 1995, Yildirim, Baur & LaBoube, 2014).

Curriculum assignment and domain knowledge training for design students are typically designed to mimic industry workflow with the application of integrated projects that involves learning activities like teamwork, peer review, preparing portfolios, preparing for a presentation, and critique. These will help to build industry knowledge and technical skills, but it is the real work experience that can provide an opportunity to develop personal, social, and behavioural skills (Guile & Griffiths, 2001). The internship programme in the curriculum aims to help a student to advance the goal to develop critical skill sets like learning initiative and self-learning (Seow, Pan & Koh, 2019). Scaffolding the internship programme structure is essential for the students to acquire new skills and aid their cognitive development (Lourenço, 2012).

The current generation of students was assumed to be highly digitally literate and values feedback in their learning, which are key characteristics identified in other studies about the newer generation of learners (Barnes, Marateo, & Ferris, 2007; Oblinger, 2004). They also displayed a preference for autonomy and independence in learning (Barnes, Marateo, & Ferris, 2007). Various self-directed learning (SDL) initiatives can be weaved into the curriculum or the internship programme for a better match to their preferred learning style. The use of SDL can prepare the student for future lifelong learning and empower the students to customize their learning, and better develop their character and skills (Gibbons, 2003).

In 2016, SP Internship Department (INP) introduced Enhanced Internship Programme (EIP) in response to the government's SkillsFuture initiative with key features like structured training, pre-defined learning outcomes, and mentoring elements. It indicated an emerging need to shift from traditional industrial training to a more curated and structured design to be better prepared and guide learners for this Volatility, Uncertainty, Complexity, and Ambiguity (VUCA) world (LeBlanc, 2018). From the 2020 cohort onwards, the result of the Internship Programme was tabulated into the student's Grade Point Average (GPA). This is a follow-up from the school-wide response to align with the SkillsFuture initiative (www.industry.sp.edu.sg). However, the impact of its inclusion in the GPA tabulation and the use of SDL elements in the Internship Programme will be excluded from this study due to the lack of data for comparison.

The Purpose of the Study

Singapore Polytechnic (SP), Diploma in Landscape Architecture (DLA) is a three years full-time project-based design diploma from the School of Architecture and the Built Environment (ABE). DLA students will be enrolled on the internship programme in Year 3 of their study. A student must complete and obtain a passing grade for a 12-week internship programme before graduation. Curated by the DLA Course Management Team (CMT), the DLA learning framework seeks to guide teaching staff in the planning of DLA projects and learning activities (Figure 1).

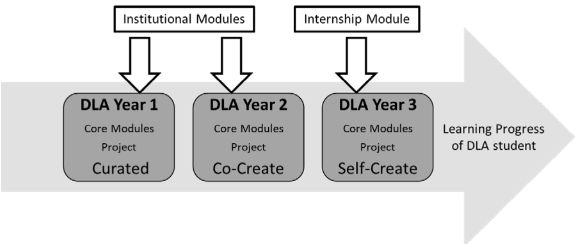

Figure 1. DLA Learning Framework for Projects & Learning

This paper will share and discuss the use of SDL initiatives that were applied to the DLA Internship program from 2016 to 2021 (the study period); integrated with EIP key features. The introduction of self-directed learning elements aims to empower students to take more ownership of their internship learning and better prepare them for real-work challenges.

1). What are the main issues of using the SDL elements in the internship context?

2). What are the views and observations of design students towards the SDL elements in the Internship Programme?

Through seeking answers to these questions, this study will review and evaluate the development of SDL in the DLA internship programme, and discuss the findings to raise recommendations for future application and development.

DLA Internship Programme

A pre-internship briefing is conducted six months before their internship to prepare them for the internship preparation tasks ahead. During the internship, all students need to keep their learning progress in an internship journal (provided by the SP Internship Department) to keep their internship records, and grading documents. This file folder aims to help the student, company representatives, and SP liaison officer (LO) to track internship progress and performance. Each diploma is allowed to make minor changes to the record forms to fit individual diploma needs. Hence, the DLA internship journal was modified to facilitate more SDL elements for self-review and feedback purposes.

Due to the Covid-19 pandemic in 2020, DLA created an editable Portable Document Format (PDF) version to facilitate the completion of learning records digitally. This enables online communication and review process of the journal by the company representatives, and LO without physical contact. DLA also introduced the Alternative Internship Programme (ATI) to help students affected by travel restrictions or withdrawal of internship placement by companies. For ATI, an experienced industry professional (accredited landscape architect) was assigned to each student as their mentor during the internship period. These professionals volunteered their service as part of their continuous professional development and passion to contribute to the education of our students. Due to the lack of a company and real project, ATI students' training plan will be aligned to individual learning needs or learning outcomes that are achievable in this context.

From the observation of participants (company representatives, LO, and students), they can be generally categorized into two groups based on their different perspectives on the internship programme:

The Believers: Believed that the internship is a platform for future engagement with the design industry. Company representatives are likely to have benefited directly from the previous internship programme or see the benefit of getting involved. They are generally more passionate about educating the next generation of designers. The students are likely to be above-average performing students who aim to stay in the industry and may also be seeking an opportunity for scholarship from internship companies they worked for. The major considerations for this group are: What can they learn from the internship? What are the background and prospects of the internship placement company?

The Followers: Readily accepted the internship as a requirement to complete higher education or a requirement by the school or from company management. Company representatives tend to be 'assigned' the role and may regard it as an additional workload. They usually do not have high expectations of performance or learning outcomes during the internship. How to complete the internship programme? What is my role? What are the tasks of the internship? These are their major concerns for this group. Some students indicated that they expected the school to be responsible for getting them the 'correct' internship company and see it as the duty of LO to help them complete their internship. Their mindset has a misplacement of self-responsibility or does not see the value of enquiring about the skillsets to plan for their learning.

Different self-directed learning elements were integrated into the internship programme progressively to observe the impact and allow for timely modification. The common goal is to encourage students to plan and curate an internship training that fits their needs and the company's contextual situation. Online training and briefing are provided to guide students. Refer to Table 1 for the list of various SDL elements integrated into the DLA internship structure from 2016 to 2021.

Table 1: SDL elements in DLA internship programme structure from 2016 to 2021

Year	Number of Students enrolled in internship	Non-GPA / GPA	Number of Company involved in internship	Self-Directed Learning Element in Internship Programme
2016	34 students	Non-GPA	19 companies	• Student select company from list • Pre-defined training program
2017	34 students	Non-GPA	19 companies	• Self-sourcing placement (assisted by LO) • LO planned training program
2018	34 students	Non-GPA	21 companies	• Curate E-Portfolio • Self-sourcing placement (assistance offered only when required) • LO & Student co-planning of training program • Reflection report
2019	37 students	Non-GPA	18 companies	• Curate E-Portfolio • Self-sourcing placement (pre-approved list provided) • LO & Student co-planning of training program • Reflection report • Feedback record
2020	23 students	22 GPA 01 Non-GPA (student from 2019 cohort)	14 companies	• Curate E-Portfolio • Self-sourcing placement (pre-approved list provided) • Student & Company representatives co-planning of training program • Reflection report • Feedback record with follow-up action record • Improvement plan • Readiness Checklist
	05 students	05 GPA	05 accredited landscape architects	Alternative Internship Programme (ATI) • Student & Company representatives co-planning of training program • Reflection report • Feedback record with follow-up action record • Improvement plan • Readiness Checklist • Online self-learning (Coursera)
2021	34 students	GPA	20 companies	• Curate E-Portfolio • Self-sourcing placement (pre-approved list provided) • Student & Company representatives co-planning of training program • Reflection report • Feedback record with follow-up action record • Improvement plan • Readiness Checklist • Online self-learning (Coursera)

Methods

The selected participants are involved in Singapore Polytechnic, Diploma in Landscape Architecture (DLA) internship programme from the Year 2016 to 2021. This study will adopt the use of a quantitative research approach to explore the research questions and gain more understanding. Upon the end of the internship programme, all students received an online survey to share their thoughts on the internship. Participation in the survey was voluntary with no implication for their module grades. The students were requested to respond within two weeks from the end of the internship to ensure that their memory was fresh and reviews were more reliable. Refer to Appendix A for the survey questions.

By the end of the study period, a total of 65 DLA students completed the survey within the stipulated deadline, including the five students who completed the DLA Alternative Internship Programme (ATI) in 2020. Informal conversations were also conducted with the company representatives to gather their opinions on the changes to the internship programme and their observation of the student's responses to SDL initiatives. Their perspective and feedback served as valuable references for the evaluation and discussion. Race, gender, and internship grade of students were not taken into account for the analysis of the results.

Student Participant: They have an age range between 18 to 21 and came from two DLA student classes: Class 01 and Class 02. A pre-internship briefing was conducted to help them better understand their role, duty, and application of SDL components. Online training for students was provided and must be completed before the start of the internship period.

Company Participant: All companies must be capable of providing related industry training and shall assign company representatives (a training supervisor & guiding mentor) to work with the DLA student attached to their company. Training for company representatives was launched on an online platform to facilitate self-learning based on their schedules. They must complete a compulsory quiz to ensure their understanding of the requirements, role, and SDL components of the DLA Internship programme to help them work better with LO. The training supervisor & guiding mentor could be the same person within the company. Both company representatives and LO need to work together to monitor or guide the students during the internship period. If the facilitators are clearer about the structure, it will help the students perform better and motivate them (Douglass & Morris, 2014).

Results and Discussion

As part of the DLA internship requirement, each student must outline and achieve six pre-defined learning outcomes, complete and submit module assignments, attend two internship workshops, and maintain an Internship Journal as a learning record. Key self-directed learning elements designed for integration with internship requirements include self-sourcing placement (before internship), self-planning of the training program (with company representatives), Reflection report (during internship), and Feedback record with follow-up action (monthly review).

Students and company representatives accepted the SDL elements as part of the internship training or school requirement. Some did raise questions and provided feedback which lead to progressive changes and improvements to some of the design and workflow of the internship programme. The discussion will be structured to discuss views from both student and company participants following the sequential application of self-directed learning initiatives during the internship period for ease of understanding:

Self-sourcing placement: Each student has to create an e-portfolio and select a desirable company from the provided list of DLA-approved industry-related companies. They will need to send their application to the desirable company to seek an internship placement. This process leverages their prior institutional module training (Year 1 & 2) in resume writing and interview training and builds their real-world experience, enhancing their skillsets. Students will also regard the sense of autonomy as empowering and increases their intrinsic motivation if given a chance to self-direct their learning. (Douglass & Morris, 2014).

Some students who learned of past practices of direct placement by school raised questions about the self-sourcing requirement. The main concern is the lack of confidence to secure the internship placement independently and uncertainty of the protocol to communicate with a company. Some students shared that this intriguing self-sourcing process became especially rewarding when they were offered placement based on their merit, effort and resourcefulness. They gained valuable experience similar to a real job application process. The self-effort to secure the placement is also critical to increase their ownership of the entire internship process and become more appreciative of the hard-earned learning opportunity.

Based on the survey findings, these are some reflections on the self-sourcing process:

"Must source for multiple companies to get a better chance in scoring the interview. It is also important to review the design of portfolios and resumes in order to capture their attention." – Student A

"The interview gives me a good experience that related to the real working environment with the need to research on the companies, send various emails and attend an interview. I learned the different requirements of a company." – Student B

"Learning to accept rejection is a worthwhile experience for real job applications in the near future. Must learn to move forward, don't give up." – Student C

Most students tend to apply for multiple placement applications to increase their chances of getting an internship offer. They may be required to reject offers without the company taking offence to their decline. For students with this happy problem, they need to be professional with their communication due to the common understanding that our industry is small and hence has a closely-knit network. On the other hand, some students may face setbacks from multiple rejections despite being active in their sourcing process. DLA will provide additional guidance to these students to realign their options or motivate them. However, the student needs to conduct self-reflect on their method or weaknesses. Nonetheless, successful completion of this step of the internship will eventually contribute to their resilience training and help them handle their post-diploma job searching process.

Most of the companies are repeat participants in the DLA internship programme with prior experience working with DLA students. The introduction of the self-sourcing placement initiatives to the internship programme was welcomed by the company as it enables them to understand the capability of the student before the start of the internship or even their commitment to participate in the internship programme. This initiative will find a better match for students and the company according to their needs, but it may also lead to no match and eventually cause DLA to lose the placement. However, the successful completion will help to manage the expectations of both the student and the company, reducing post-placement conflicts which mainly arise from misalignment in qualities or skillsets during the internship pairing. It allows the company to adhere to its selection criteria, and offer placement only when a student is found to be suitable. The mutual agreement by participants in the initial selection stage will strengthen the commitment to complete the internship programme together. The experience of the interview will also enhance the student's communication skills and ownership of their internship.

By allowing self-sourcing and mutual selection (placement) between students and companies, academically stronger students were initially expected to find a match more easily. However, the self-initiative of students to track their application seems to play a much bigger role to impress the company and secure the final placement. Some company representatives shared that they will give higher priority to students who showed more interest in internships with their follow-up email or phone call; displaying a positive learning attitude.

Co-planning of training program: The formation of a training program between the student and company representatives is another critical step of the internship. The key learning outcomes from the training program have to be mutually agreed upon to facilitate a more meaningful internship. Firstly, all participants need to complete pre-internship training (online) to have a good understanding of the programme structure and requirements. Next, the students need to craft their training program guided by pre-defined learning outcomes curated by DLA CMT before discussing with their mentor to confirm the suitable learning outcomes. Eventually, the students need to manage their learning expectation as each training opportunity are based on different job scopes and project timelines, subject to the availability of student capability too. The company representatives entail a high level of commitment from the staff involved. It prompts the company representatives to review their mode of working with students. For the supervisor, the staff need to discuss and plan the training with the student for clear learning outcomes. For the mentor, it elevated them to a guardian-like role that is beyond traditional task-orientated duties. They need to offer knowledge beyond the typical domain knowledge training, which may include career advice. The company also need to understand that their staff will need to set aside considerable time to work with LO and the students; an acknowledgement of the staff's contribution to the internship programme.

Up to 93% of the student shared that they can decide or plan what they want to learn during the internship; selecting their learning outcome. While 7% of the student indicated otherwise (Figure 2). Upon review, it is found that these students are either interning in a company with restricted resources or limited by the project type available in the company. As a result, they lose the opportunity to have autonomy or choice over their learning plan.

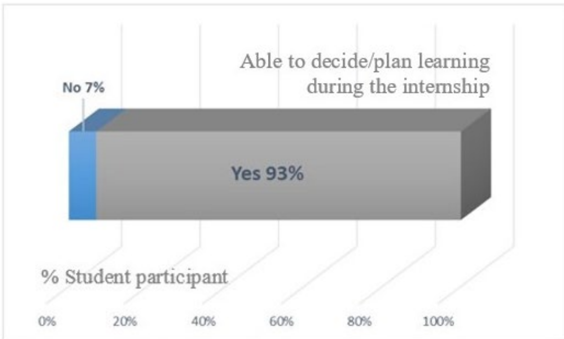

Figure 2. Students relate to their ability to self-plan for internship learning

For example, a student attached to a company with mostly overseas projects cannot expect the fulfilment of site-based learning outcomes due to a lack of local projects. Another student attached to a big organization was subjected to job rotation between different departments during the internship period and needs to change the initially planned learning outcomes to fit the new learning environment or work scope. Changes are inevitable and some students must take the initiative to craft new learning outcomes arising from new opportunities while staying mindful of the contextual situations. The presence of uneven opportunity is inevitable in the real world and must be acknowledged. The negotiation process is a delicate and sensitive process that even working adults may find it hard to openly discuss with their superiors. This ability to handle

or accept changes will result in valuable learning beyond the classroom; a reflection of the VUCA world (Seow, Pan & Koh, 2019).

Another common issue is the failure to follow the training program as crafted. This usually happens when there is a change of company representatives or project schedule during the internship period. In event of changes to the training program, students must take on the responsibility to update LO and document the changes accordingly for review purposes. Uneven opportunities will also occur when two students was attached to different staff in the same company. The students may have different training opportunities and need to manage their expectations. The company representatives and LO need to monitor the imbalance and mitigate the gap in learning opportunities in such a scenario. Nonetheless, it also offers an opportunity to promote peer learning between themselves whereby the students will gain additional skillsets while enhancing their domain knowledge at the same time. Most importantly, the students need to acknowledge such issues as real-world problems and managed their expectations along the process.

Feedback Record & Improvement Plan: Another key self-learning initiative is the addition of a task-based feedback record. An encouraging 97% of the participants responded that they have been receiving feedback on their work during the internship (Figure 3). The remaining 3% was found to have received little or incomplete feedback from the company representatives occasionally.

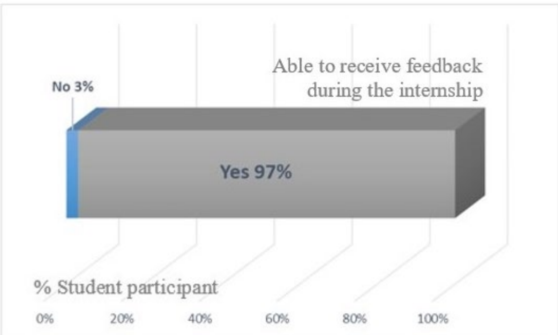

Figure 3. Students relate to their ability to receive feedback during the internship period

The record is modelled after a consultation feedback record that was originally designed for the DLA design studio consultation session. The aim is to allow students to summarize their learning after each consultation, with follow-up action/reflection before the next consultation. Both students and tutors find this record useful to track project learning and hence, the feedback record was modified for application in the internship.

When the feedback record was first integrated as part of the internship record requirement, it was observed that the feedback records were not timely recorded. Students have difficulty keeping track of the changes as the pace of internship work is much faster compared to school work. Some of the students also have difficulty in finding the time for a proper consultation with the company representatives as the feedback record requires the company representatives to check and confirm the follow-up action, which is rarely achieved or completed. After a few discussions with the company representatives and students, the feedback and action record were revised to be part of the weekly record in lieu of task-based.

As a result, the company representatives will have an opportunity to review the records collectively for their monthly review and grading. Subsequently, the student has to create and complete an improvement plan in addition to the feedback record. This enables a meaningful conversation between the company representatives and students during the monthly review. The recording of the feedback and creation of an improvement plan requires commitment and time from both participants to complete this task. It serves as a good reference and evidence of the student's learning process while prompting self-reflection. The improvement plan also indicated the student's application of learning from the company representatives' feedback. It also serves as excellent review reference material for the company representatives and LO grading at the end of the internship.

Changes due to the Covid-19 Pandemic

In 2020, most of the students and company representatives were required to work from home due to the pandemic. Everyone needs to learn the techniques of communicating effectively by digital means. During this period, students were anticipated to have a more flexible training program, fewer learning opportunities, and limited time with company representatives as they were not in the same physical environment. Hence, DLA worked with the SP library to create an additional resource webpage to curate industry-related learning materials, with self-learning videos on domain topics to enhance students' knowledge. In addition, the students were provided with a school license to access an external online learning platform (Coursera) for additional online short courses, which some students even earned a certificate.

DLA created a digital editable version of the journal for ease of digital updating by all participants, and internship grading was collected with an online response form in place of the office-endorsed grading sheet. Interestingly, company representatives were observed to be more open in sharing critical feedback when using the online form. This could be due to the opportunity (more time) to recollect their thoughts before providing their feedback. As a result, the monthly grade and feedback were timely shared with the student and respective LO, promoting better review and reflective action. The ability to collate more critical feedback also enables a better evaluation of the programme for future internship models.

For the Alternative Internship Programme (ATI), the key challenge was primarily the lack of company social

environment, project-based learning, and contextual learning. Administratively, the quality of both normal internship (with a company) and ATI requirements must also be on par to ensure consistent grading criteria within the same cohort of students. Therefore, the pre-defined learning outcomes, journal record tasks, and access to mentorship remain the same for both normal internship and ATI. Each ATI student was also assigned to an ATI mentor (an accredited landscape architect) to provide the same access to mentorship and professional guidance. Most ATI mentors make use of their past projects to frame the learning scope for the student; one ATI mentor even registered her ATI student for an international competition to set a tangible goal for learning. Another mentor with both groups of students (normal internship and ATI) under his mentorship for the 2020 internship period, observed that the ATI student needed to make more changes to the training program as the pace of self-learning requires constant adjustments.

Here's some feedback shared by ATI students after completion of the internship:

"ATI provided me with a chance to study topics which I am not familiar or weak, based on my own timing and schedule, using Coursera." – ATI student 1

"ATI was a good experience as I learned a lot from both my mentor. I manage to conduct a few in-depth conversations with my mentor which helps me to polish some skillsets and see my weakness." – ATI student 2

"Even though ATI gives me new learning experiences but I felt that I am not able to have a real internship experience with a company and learn how they work in a real project." – ATI student 3

ATI students gained a unique internship experience with a higher level of autonomy and self-control in their learning. Compared to their peers on normal internships, some ATI students do wonder what they have missed due to the limitation of ATI that was completed without an office or real project training. They felt that the real working environment learning cannot be fully replaced as the absence of a social office structure will not present real-world problems or experience. Nevertheless, all of them acknowledge the benefits of self-discipline training and the importance of SDL skills.

Limitation

With changes being implemented over the entire study period of six years, the student, company representatives, and LO need to stay abreast of the changes and requirements. Online training material about the new initiatives were created, updated and provided to all participants to stay relevant and provide desirable learning opportunities. However, the level of application remains uneven due to varying commitments to the program and the SDL initiatives. Some self-learning elements may not work well because of the variation in the work environment context. In addition, it is challenging for students to understand the benefits of SDL at the start of the internship. Even though most of them only need to perform an internship once and do not have the opportunity to review, practice or redo the process for the better.

Prior project and technical skills training laid the foundation to prepare the design students in terms of domain knowledge for the internship programme. Therefore, work performance during the internship and module results will not be part of this discussion due to different pre-defined learning outcomes, and training programs.

Discussions in this study are based on data from observation, review, and evaluation of survey results from only 35% of the total number of DLA students who have enrolled in the internship programme, completed the internship programme during the study period and experienced the use of SDL elements. Responds to this survey are voluntarily, hence resulting in a significantly lower number of survey respondents compared to the total number of internship students during the study period. Henceforth, the survey can be made compulsory for all internship students to yield more results for better evaluation in future studies.

Conclusions

Since different SDL elements were introduced to the internship programme from 2016 to 202, it presented an opportunity to review the existing structure and iterate on the design for integrated applications. A progressive change allows for continuous review and offers an opportunity to review the programme design based on feedback and responses from participants.

Self-sourcing is the first task that the students have to learn; before embarking on their internship programme itself. The preparation works provided an opportunity for the students to reflect on their skillsets and acknowledge their level of competency. Such a process may be daunting for some students but will become rewarding when they manage to get the placement based on their effort or merit.

Overall, the students and companies supported the switch to self-sourcing although it may mean more upfront administrative work for them. It helps companies to define required skillsets and for students to outline their expectations; to find the best match for both parties. Some students appreciated that they have the chance to decide on a suitable internship company based on their interests or priority; some thought of the potential for future job prospects while some simply look for proximity to their home. Companies have the benefit of conducting a proper interview selection process before offering placement to suitable students. Some companies also deem the internship programme as a stepping stone to identify, recruit and groom potential future staff. Some students were offered a scholarship to advance their knowledge which makes the sourcing process an important step. All parties can make informed choices

and pursue their projected goals, making better sense of this internship experience.

Communication and training are important factors to the success of the internship programme due to the multiple parties involved and the complex requirements of each company. All participants need to be aware of their role in the internship programme. Changes and updates to the internship structure need to be communicated to students, company representatives, and LO. The SDL elements require dedicated effort by facilitators to coach, provide guidance, and timely feedback for success (Gibbons, 2003). DLA created online training material to help all participants learn and review the requirement of DLA internships and SDL easily. This works well for busy industry professionals who can complete the training based on their schedule and convenience. Students and LO also have access to similar online material for their requirement alignment, which works like a checklist for internship assignments and tasks.

The change in internship programme also prompted the companies to identify suitable full-time staff to assume the roles of company representatives for the internship programme. This may be seen as a form of staff capability development as staff identified for the company representatives role requires a high level of domain knowledge, effective communication skills, and the ability to mentor the students. As a mentor, the staff must also understand the implication of the role and its impact on the student's learning. The responsibility and stakes are high and should not be taken lightly.

DLA implemented the ATI programme during the 2020 pandemic period, which was offered concurrently with the normal internship. Both groups have the same requirement of SDL elements but the requirement for self-discipline is noted to be higher for ATI students, due to the lack of company structure support. With the projected difficulties and the known lost opportunity to add the internship company to their resume experience, the students may not voluntarily select ATI if offered during pre or post-pandemic. Nonetheless, the ATI programme is seen as a unique model due to the pandemic situation which can be readily reactivated as an alternative solution when a similar situation occurs again. This could also lead to a new option for future internship programmes, or can potentially benefit students with special needs or limitations in learning ability.

With the proposed longer internship period for future DLA students, a separate study can provide new insights into the impact of different SDL elements on module performance. The impact of GPA tabulation on students' outlook on the internship is also another possible area of exploration.

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Appendix A: Sample survey for student

Sharing on Internship Programme

Relate your personal experience from DLA Internship Programme. Your honest review will contribute to a review paper on the Internship Programme. Thank you.

Question 1. Indicate the year of your internship programme

Question 2. Did you complete your internship programme?

Question 3. Briefly describe your experience of self-sourcing placement:
Example. What did you learn in the process, relate the difficulties or experience of this process?

Question 4. Did you manage to decide/plan what you want to learn during the internship?

Question 5. Did you receive feedback about your work from the company representatives during the internship?

Question 6. Did you conduct self-reflection on your Internship performance (during or after)?

Question 7. Did you do an improvement plan during your internship?

Question 8. Do you agree that an improvement plan based on feedback should be self-directed by the intern?

Question 9. Explain your answer above

Question 10. Briefly share your opinion on a longer internship: Example. 6 months

*Additional Questions for students who participated in DLA Alternative Internship Programme (ATI) 2020

Question 11. If given a choice, will you voluntarily participate in the ATI?

Question 12. Explain your answer above

Question 13. Rate your overall experience with ATI 2020

Question 14. If the internship period is 6 months (or longer), do you think the ATI should be offered as an option (by choice)?

Question 15. Briefly share your thoughts about ATI

Question 16. Explain your answer above

SHARING OF WORKPLACE LEARNING AND ASSESSMENT EXPERIENCE IN HIGHER DIPLOMA IN ANALYTICAL SCIENCE

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Abstract

The testing sector in Hong Kong drives a rapid growth in the world and has established various types of services quickly in response to market needs. The sector has high technical competence which Hong Kong is in a leading role. To develop new types of services, technical capability of staff is one of keys to success. A high proportion of professionals is required in the sector. Higher Diploma in Analytical Science in Hong Kong Institute of Vocational Education (Sha Tin) has well established education and training to youngsters to provide the necessary manpower to support the development of the sector. In 2017, Higher Diploma in Analytical Science has integrated structured vocational education and on-the-job training from employers to equip students with knowledge and skills in workplace under VTC Earn and Learn Scheme. The workplace is ever changing with developing challenging services to market. To further enhance the effectiveness of on-the-job training in workplace, Workplace Learning and Assessment is incorporated in Higher Diploma in Analytical Science in 2019. Employers who participated the scheme provide structured workplace learning and assessment for students. Throughout the scheme, the assessment is developed by referring to specifications of competency standards in testing industry. Students can earn authentic training from employers and assessed in real workplace. The assessment is a competency-based approach which enhances developing capabilities of students for the industry. This paper outlines the design of Workplace Learning and Assessment approach used in Higher Diploma in Analytical Science in Hong Kong Institute of Vocational Education (Sha Tin). The learning experience serves as a framework to equip students with relevant technical skills in testing industry and with sufficient opportunities to shape them to be confident to work independently. Student performance and feedback on Workplace Assessment have been positive. Workplace Assessment results showed competencies of students and effectiveness of learning experience in workplace. In addition, students provided feedback that they enjoyed learning and being immersed in real workplace. They can acquire necessary competencies and develop independent learning skills in which they possess lifelong learning skills to be competitive in workplace.

Keywords: *VTC earn and learn scheme, workplace learning and assessment, competency-based approach, analytical science*

Introduction

Learning is commonly recognized as comprising a series of presumed activities to obtain designated knowledge. Learning activities enable students to take what they have learnt from participating the activity and use it in another context, or for other purpose (Lave, 1993; Constance, 2018). Students deploy and change the ways to gain their knowledge and cognitive experience by participating school activities and interactions. The process of learning is continuously throughout different testing, continuous reflective observation, and practical experiences and repeatedly practice (Munna and Kalam, 2021). Continued practice is an important factor in any learning operation. Besides, it is realised that instant feedback enhances the whole learning process. Workplace assessment for learning is an effective way to teaching and learning in which providing adequate feedback to improve students' performance. To enrich student learning activities in Higher Diploma in Analytical Science, Workplace Learning and Assessment (WLA) is incorporated in the programme in 2019. Students can hone their knowledge and professional skills in analytical science throughout on-the-job learning and training to meet industrial needs. To enhance an effectiveness of vocational education, learners equip knowledge under structured workplace learning and conduct assessment in the workplace.

Workplace learning carries characteristics influencing skill-based learning, in which emerging from interaction between individuals and practical setting

(Woerkom and Poell, 2010). Workplace learning differs from school learning, it is oriented towards employment and professionalism (Billett, 2008). Workplace assessment also differs from school setting. It is embedded in the routines of the workplace and learners get benefit from opportunities of communication and interaction with experienced workers. Learners gain cognitive problem-solving in decision about routines in the workplace from direct guidance or indirect support of experienced workers.

Higher Diploma in Analytical Science aims to fulfil the VTC mission of providing a valued choice to school leavers and working adults to acquire values, knowledge and skills for lifelong learning and enhanced employability as well as valued support to industries for their manpower development. It can seek to cultivate a habit of lifelong learning and train student's ability to learn how to learn.

Specifically, Higher Diploma in Analytical Science equips students with the technical and professional knowledge in Testing Industry and enable them to pursue a career in the industry. It is the most important that the industry is built upon a workforce of professionals with high level of integrity and technical expertise. To step up efforts in strengthening the industry's manpower resource, the industry develops its work-based competency standards to guide effective manpower preparation in anticipation of the business demand. To work closely with the industry, the industry supports to operate workplace learning which is adopted in Higher Diploma in Analytical Science. The programme integrates structured classroom learning with on-the-job training to meet the industrial manpower needs.

This paper is based on an initial observation of Workplace Learning and Assessment operation in Higher Diploma in Analytical Science between 2019 and 2021. It aims to develop a more effective model for communicating with different stakeholders in running Workplace Learning and Assessment. It is significant to evaluate student performance and collect feedback from different stakeholders. Workplace Assessment results showed competencies of students and effectiveness of learning experience in workplace. In addition, students can acquire necessary competencies and develop independent learning skills in which they possess lifelong learning skills to be competitive in workplace.

Workplace learning mode

There are different learning and teaching models for vocational or competency-based training, such as in-house traineeship; industrial attachment; work integrated learning; and workplace learning. In-house traineeship allows for coordination between workplace and learning activities in classroom. The company offering in-house traineeship is usually a registered training provider. Industrial attachment is a kind of post-training placement. Students studying Higher Diploma in Analytical Science would be arranged to conduct industrial attachment in the final semester. Students are equipped with relevant skills and knowledge and attain interpersonal skills in the industrial attachment. Students also gain working experience and identify their own strengths and weakness in relation to working. Industrial attachment is quite common and key learning activity for vocational training education. Work integrated learning aims at developing student competence through a combination of academic and work-related activities. It is an experiential learning and internships. There are different interpretations based on the application thereof.

Workplace learning aims at equipping students with knowledge or skills by all means that occurs in the workplace. Mostly, it operates in an apprenticeship model. Workplace learning somehow is prescribed as a process which is informal, based on experience and shaped by work activities and context. It is an intangible learning because there is no clear and specified learning outcomes. In this paper, we share how both informal and structured on-the-job training take place and how learning outcomes are assessed through all processes.

The pedagogy of workplace learning is totally different from pedagogy applied in classroom setting. The latter one is formal restricted teaching with reading and written typed papers whereas workplace learning is by means of self-observation and repeatedly practice (Dornan, 2007). The curriculum of workplace is quite a dynamic process. Even incorporating elements of simulated practice in the classroom, it cannot replicate the full complexities of the workplace. Workplace is not a simulated setting for application of knowledge. It definitely embeds the culture, norms of practice. Students in the workplace undergo the process of enculturation into a workplace context. They inaugurate development what is acceptable behaviour and working attitudes.

Developing unit standards for workplace learning and assessment (WLA)

There is a substantial study to understand the significance of competence in the context of workplace (Hyland, 1997; Lester, 2014; McClelland, 1998). Unit standards are the building blocks of attaining qualification. A unit standard describes the intended learning outcomes to be attained by the trainees, as well as the assessment criteria set in which the trainees; performance can be overviewed and judged. These unit standards are the basic levels of competency as recognised in the industry. Unit standards specify what a learner for assessment needs to know, do, and understand. Whether it is by task or evidence, assessment can use a variety of methods and approaches in which are appropriate to the candidate and the context. It is necessary to give the candidate the opportunity to show competence (Scholtz, 2020).

To develop unit standards for WLA in Higher Diploma in Analytical Science, it is in reference of units

of competency in the Specification of Competency Standards (SCS) for Testing, Inspection and Certification industry. SCS was established in 2010 under qualifications framework by the industry training advisory committee of the Testing, Inspection and Certification industry. It consists of 242 units of competency which are distributed in 7 major functional areas at various qualifications framework levels (Qualifications Framework, 2019).

With reference to the requirement of units of competency developed for industry and taking into account of the applicability of operation in the workplace, especially learning outcomes in the curriculum of the learning programme. The unit standards for WLA established not only fulfilment or attaining the competency of a job or a position in the industry, but also achieving learning skills throughout work experience with practice in the context of the of the workplace. The unit standards are effective tools to provide clear objectives, competence skills and last but not least, learning outcomes of the context. It aids to achieving the programme intended learning outcomes. It therefore contributes to the content of curriculum.

To ensure quality of structured on-the-job learning and work experience, unit standards are developed with appropriate implementation plan and schedule of workplace learning. Learning outcomes are clearly defined and corresponding forms of assessment context are designed. Training activity plan is designed to equip trainers with appropriate readiness and understand the context in assessment tasks.

There are 5 sets of unit standards are established and adopted in the programme curriculum.

1. Handle and perform equipment calibration
2. Perform equipment maintenance and performance checks
3. Calibrate and maintain reference standards
4. Apply extraction techniques to organic analysis
5. Handling samples

Training activity for each unit standard is supposed to be conducted within 10 hours. Trainees can integrate the first three unit standards in the same testing method in the workplace. Unit standards related to extraction techniques and sample handling require longer training hours as there are various techniques in sample pre-treatment. In order to refine the scope of extraction techniques and sample handling, it is significant to collaborate with employers to assess appropriate level and context.

Assessing workplace learning

Burchell, Hodes and Rainsbury (1999) suggested that employers value both technical competencies and soft skills. Any assessment, therefore, could address all skills gained in the workplace, including interpersonal skills and ethical professional skills which are developed within the workplace. The trainees' assessment of workplace learning can be formal and restricted based on predefined criteria and range to evaluate the competence of trainees. It can also be unstructured that instant feedback are provided to inform trainees during practice. The assessment can be a combination of both (Zegwaard, Coll, and Hodges, 2003).

In Testing, Inspection and Certification industry, assessment always includes assessing skills as well as trainees' attitudes towards work and learning. It is obvious valuing of learning at work and time allocation for learning to take place. Trainees could have reflection on learning process and capturing problem solving skills. It is an important aspect of competencies which are not easily captured through restricted assessment processes.

It is obvious and easily to rank technical competencies at different rating. As it is too much emphasis on micro-skills of practice, trainees usually miss the essence of what it is to be a learner in the workplace. Trainees are required to complete all tasks assigned in workplace assessment and show their capability to meet the criteria of these tasks. They can experience learning skills through daily practice and receive instant feedback from supervisors. Trainees take more active role in the learning process and gain interpersonal skills.

Throughout writing a reflective journal of learning process in the workplace, trainees can self-reflect on learning process and identify significant learning activities in the workplace. It is more in-depth to assess trainees' development and trainees can evaluate their own strengths and weaknesses as a practitioner in whatever working environment they are engaged in. It is more long-term benefit on development of an individual capability.

All workplace assessment context and criteria would be undergone moderation to ensure that they are fit for the purpose and appropriate to the level. Post-assessment moderation is significant to maintain the consistency of assessment judgement. Throughout the post-assessment moderation, it ensures classroom learning can be extended to workplace. Communication with supervisors are integral to workplace learning experience and validity in assessments.

Observation

There are four trainees joining the workplace learning and assessment and no survey or questionnaire are conducted to collect students' feedback on learning experience of workplace learning and assessment. Instead of conducting survey, group interview is employed to realise their learning experience. Trainees commented that it is definitely a student-centred learning as they have to take an active role in seeking further support after training activity. They may not grasp the skills during the training activity. They need to practice in daily working environment and also learn by observation. It is totally different from learning in the classroom. They attained satisfaction as they can achieve the work.

Trainees learnt to have good time management as they need to show their competencies by collecting evidence, such as video recording of the work, result of the experiment. They also communicated with workplace assessors if collected piece of evidence is sufficient enough to show the competency. Throughout the communication, trainees understand the perspective of the task and gain instant feedback to improve technical skills.

These four trainees are assigned to different mentors in the workplace. The important of conduct, demeanour, emotional intelligence and communicative abilities are significant factors in learning process in the workplace. Besides learning technical skills, trainees realise the crucial of soft skills to have effective workplace learning. It is a socially-mediated learning process and socially derived cognitive experience.

Conclusion

Trainees joining the workplace learning are studying the Higher Diploma in Analytical Science under VTC Earn and Learn Scheme. Higher Diploma in Analytical Science has integrated structured vocational education and on-the-job training from employers to equip students with knowledge and skills in workplace under VTC Earn and Learn Scheme. The constructive and interactive processes lead changes to individual trainee during the workplace learning. It occurs continuously to transform workplace skills in work-related activities. Beyond planned training activities, trainees gain self-centred learning experience and attain self-esteem and confidence in workplace learning. Assessment of workplace learning is challenging to workplace practitioners and school coordinators. The context and criteria of assessment required in-depth understanding of job description and technical skills in the trade. As the workplace learning is socially-mediated, assessment may take into account of soft skills of individual learners. Workplace learning and assessment is one of effective pedagogies to provide a clearly defined the study in Vocational and Professional Education and Training. Also, it allows students with apt opportunities to demonstrate skills and attributes in the trade and align with curriculum intended learning outcomes.

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STRATEGY AND COLLABORATION WITH STAKEHOLDERS IN NORTH KINKI REGION

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Abstract

In 5 cities and 2 towns in the northern part of Kyoto Prefecture have revealed their respective policies and measures that are related to the regional collaboration to strive for regional development. This paper aims to propose a method to achieve sustainable activity, that is, to discover and solve the problem in collaboration with the human resource cultivation.

The overall structure is obtained by the surveying, classifying and organizing the plans and strategies of the stakeholders, such as industry, public, academia, private companies and financial institutions that are active in the North Kinki region. According to the stakeholders whose main scope of the activities concerns to the whole or the part of the region, the investigation of its philosophy, policy, and activity content are examined.

After collecting the ideas and policies of each organization, the strategies and policies of local governments, etc., a list of contents are summarized. The classification and organization of the listed contents resulted in structuring a framework including the human resource cultivation.

And the overall direction of the North Kinki region and the correspondence with the SDGs are described. The mechanism is considered, such as the realization of the policy in the region, including the construction of a regional platform to solve the problems.

The remarks through the research are as the followings.

- After concretely matching the needs as a regional issue with the seeds as a regional ability and / or potential, the project will be conceived and implemented.

- If a new and challenging project that does not seem feasible, it could not be launched, because the chance of success should tend smaller.

- When starting up, it is necessary to accommodate a company rooted in the area, in order to the business can be implemented and continued. Projects that rely on external resources often stagnate when they run out.

- The participation of the students, public, etc. related to each project can cultivate the capability of the whole region through the collaboration e.g. internship.

Keywords: *North Kinki region, Regional revitalization, Stakeholder, Future strategy, SDGs, Human resource cultivation*

Introduction

The northern part of Kyoto Prefecture has revealed their respective policies and measures related to the regional collaboration and development. This paper aims to propose a method to achieve sustainable activity to discover and solve the problem in collaboration with the human resource cultivation. The contents are along the following issues.

- classification of the future strategy including the philosophy, policy and measures, and the wholistic view based on SDGs
- current activities and a proposal for the human resource cultivation according to Maizuru college
- introducing the experiences through the on-going projects at this moment

Future Strategies of Covered Region and Organizations

Covered Region: Five cities （Maizuru, Ayabe, Miyazu Kyotango Fukuchiyama, and Toyooka） and two towns (Yosano, Ine and Takahama) in North Kinki region and adjacent two local bodies are in the scope(Figure 1), when considering the specific issues that span administrative districts, such as economic zone,

living zone, and measures against harmful beasts. The population of individual local bodies is less than 80,000, and the total population is about 300,000. There are many mountainous areas and coastal settlements, and the population is declining as the typical regional status in Japan.

Table 1 shows the population (as of 2020.10.1) of each municipality in the target area and the gross domestic product (Kyoto city 2020) of each municipality by economic activity. The total production will be 1,254.4 billion yen. Regarding the industrial structure, according to the results of a survey conducted by regional economic cycle analysis, there is no single municipality that covers the primary to tertiary industries.

According to the sixth industrialization, it is conceivable that the regions would cooperate. Also considering that the maintenance of advanced medical facilities and the maintenance and management of flood damage in the Yura river basin require large resources, it is presumed that these areas need to cooperate to promote the area also.

Future Strategies of Organizations: A survey was executed that the stakeholders of industry-government-academia-private money reports such as the Kyoto Prefecture Northern Region Cooperation Urban Area.

Promotion Council, which covers the entire 5 cities and 2 towns of Kyoto Prefecture located in North Kinki

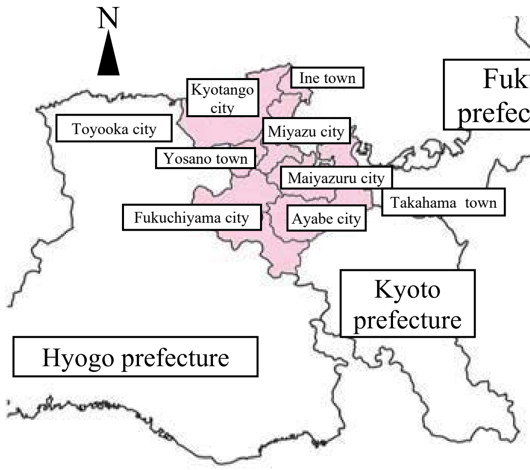

Figure 1 Target area in north Kinki region

Table 1 The status of north Kinki region

	Population 2020 . 10. 1	Gross product (MJPY)FY2017
Maizuru city	80,336	401,444
Ayabe city	31,846	153,824
Miyazu city	16,758	65,586
Kyotango city	50,860	174,346
Fukuvhiyama city	77,306	394,266
Yosano town	20,092	58,779
Ine town	1,928	6,203
summation	279,126	1,254,448

region and the wider area. Table 2-1,2-2 is the example list of these stakeholders, such as types, institution names, overall policies / management principles, URLs, stated or presumed visions, activities / measures, etc., and shows attributes such as industry-academia collaboration system / department in charge. The URL is as of September 2021.

The policies and measures of local governments have undergone public comments, questionnaire surveys, hearings from residents, and deliberation by parliaments and committees in the process of preparation, and can be regarded as reflecting the will and hope of the residents. It also shows the issues to be tackled in the region and future directions.

Classification of the Future Strategy

Four Types and Overall Direction: Issues in the region are classified into;

1) declining birthrate and aging society,
2) safety / security,
3) environment / energy, and
4) sustainability.

From four perspectives, the policies and policies are color-coded and shown in the column "List of activities and measures" in Table 2-1, 2-2. These can be regarded as candidates for issues to be researched and developed as well as responses to regional issues. QOL (Quality Of Life) is positioned as a summary of the whole, shown in red, and those related to multiple things are shown in light blue.

Policies can be categorized from four perspectives for all municipalities. For example, an aging society with a declining birthrate, population decline, transportation is for the elderly, etc. Safety and security are for health, nursing care, disaster prevention, etc. Environment and energy are for global warming, waste, etc. And sustainability is for human resource development, and startup. The above issues are to be solved, and may include R & D elements corresponding to them.

In addition, QOL can be positioned as a common item of all local governments. Keywords such as "easy to live in" and "higher income, enrichment of education, work, and housing" are collectively captured.

Evaluation of the Achievement: Since various KPIs (Key Performance Indexes) can be shown as an evaluation method of achievement, each local government has listed several ways. For example, the population will increase by 1,000 within five years. On the other hand, it is difficult to evaluate QOL. Interviews and questionnaires may be used to evaluate people living in the area. In recent years, there is a method of evaluating the buildings and communities in which they live using WELL, that is, "Well-being" does not mean that you are not sick or weak, but that you are mentally, physically, and socially satisfied. Also 10 categories are added such as air, water, food, light, exercise, thermal comfort, sound, material, mind, community. (WELL Building Standard, 2020)

Regarding global warming, GBA (Green Building Alliance) (GBA), GBJ (Green Building Japan) (GBJ),

etc. are active from the viewpoint of buildings, which are places where people live and work. They account for 1/3 of CO2 emissions, and specific certification systems include LEED, CASBEE, etc. which cover up to the scale of the city.

Correspondence with SDGs: The SDGs consist of 17 goals and 169 targets. There is a classification in which 17 themes (Figure 2) are stacked to make it look like a wedding cake.

- Natural area (6. Safe water and toilets all over the world, 13. Specific measures against climate change, 14. Let's protect the richness of the sea, 15. Let's protect the richness of the land),
- Social sphere (1. Eliminate poverty, 2. Zero hunger, 3. Health and welfare for all, 4. Quality education for everyone, 5. Achieve gender equality, 7. Energy To everyone and cleanly, 11. To create a city where people can continue to live, 16. To give peace and justice to all),
- Economic zone (8. Rewarding work and economic growth 9. Let's lay the foundation for industry and technological innovation, 10. Eliminate inequality between people and countries, 12. Responsibility to create Responsibility to use)
- Put collaboration (17. Achieve goals through partnership) at the top

This classification can be interpreted as the view of forming a society in the nature where human beings live and are collaborating while moving the economy for living. The individual themes in the policies and policies of local governments and institutions in Table 2-1, 2-2 can be positioned as individual themes or combined themes of the SDGs. One measure or activity is considered to be related to multiple themes from the start to the end, but it can be described as the theme of the SDGs corresponding to each stage. That is, each goal is related to each other.

As an example of how local governments are actually taking the initiative as a whole, there is the SDGs Environmental Future City certified by the Cabinet Office of Japan. "In promoting efforts for sustainable town development and regional revitalization, we can expect synergistic effects of overall policy optimization and acceleration of regional issue resolution by

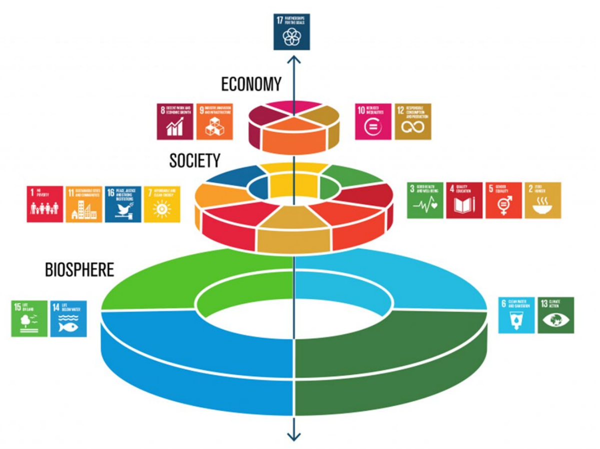

Figure 2 SDGs wedding cake model

incorporating the SDGs philosophy, so we used SDGs as the driving force. We are promoting regional revitalization (regional revitalization SDGs)" (the SDGs Environmental Future City 2021).

In north Kinki, Maizuru City and Kyotango City are certified as SDGs Future Cities. There is an explanation on each HP, the corresponding business is carried out, and the corresponding organization is organized.

Human Resource Cultivation Corresponding to Maizuru College

To achieve the sustainability : The cultivation of the human resource development and youth retentsion in the region is essential for sustainable future. Concernig to children, Maizuru college has been holding about 100 times of public lectures, on-site lessons, programming contests, etc. per year. The junior doctor training school trains human resources of science and mathematics for several months, and the trainees are from the 5th grade of elementary school to the 3rd grade of junior high school, at least 40 pupils per year. It is notable that the students of Maizuru college participate as the mentor after receiving training specialized in teaching to children (Figure 3). Since COVID-19 has spreaded, remote lecture is executed via internet as the trial for the hybrid education (Figure 4).

For the opportunities to students, Maizuru college provides the subject, the graduation research, internships,

Figure 3 STEAM education for 4-6 grades of elementary school

Figure 4 On-line practice for 2nd grade of junior high school

etc. in the form of lectures, practices, PBL, etc. The projects may be in the collaboration with the private meet various people and ways of thinking. Several practices are based on STEAM education.

The undergoing projects: The followings are the list of projects.

- The development of water level prediction system in small rivers
- IT agriculture for vegetable and green tea in Maizuru area
- IT coastal fishing by monitoring the fishery and catch forecast
- prevention from sea desertification according with the global warming
- early detection system for the person falling into water
- protection against harmful beast that give damage to agriculture
- building an IT platform with high performance PC including GIGA school initiative
- PMS (Product Manufacturing Service) in north Kinki region
- building the reginal platform of stakeholders to revitalize the region
- edge (distributed) computing with each task in the region utilizing the minimal-fab (customized IC chip fabrication)

The activities and events that students take part in often call related inhabitants, e.g. parents, related companies. This makes various opportunities where different background and idea meet. The students become aware of another way of thinking about what to do now and in future.

Remarks Through the Ongoing Activities

The reginal promotion based on the reginal potential: After concretely matching the needs as a regional issue with the seeds as a regional ability and / or potential, the project will be conceived and implemented. The regional potential is essential resource that can be used among the stakeholders. And the stakeholders have learned the following through the activities so far.

- The platform where the stakeholders in the region meet is essential to exchange the information that could not be known among them and was not recognize as the usable resources.
- After the stakeholders have become aware of the needs in the region and seeds of themselves through the discussion, the matching of needs and seeds is necessary to proceed to plan a project to solve the issues that become apparent and conscious.
- If a new and challenging project that does not seem feasible, it could not be launched, because the chance of success should tend smaller.
- When starting up, it is necessary to accommodate a company rooted in the area, in order to the business can be implemented and continued. Projects that rely on external resources often stagnate when they run out.

*The paricipation of the students and inhabitants:*The participation of the students, public, etc. related to each project can cultivate the capability of the whole region through the collaboration e.g. internship.

Acknowledgements

The related activities are executed for the regional promotion under the collaboration with the stakeholders such as local bodies, the private companies, academies, financial institution, mediaetc. In the region. Also the authors appreciate the support fund as the domestic grant program of the Toyota foundation.

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Table 2-1 List of activities and measures (partial)

mainly targeted areas		Stakeholder type	organization name	base vision			List of activities / measures (candidates for R & D issues)	
				Overall policy / management philosophy	URL	Listed or inferred base vision	Targets based on the classification of regional issues T1 declining birthrate and aging society T2 Safety and security T3 Environment / Energy T4 Sustainability Guarantee comprehensive goal → Vision, Improvement of QOL items related to multiple	URL
Wide area mainly in Northern Kansai	1	industry	a public interest incorporated association, Kyoto Industrial Association	・ Promotion of manufacturing industry in local Kyoto and development of local industry ・ Activity guidelines 1. We will promote and develop the Kyoto industry through the development of the entire business association. 2. Promote practical businesses that are useful for corporate activities in the new era. 3. We will deepen cooperation with related organizations and strengthen the information transmission function.	https://www.kyokogyo.or.jp/	Regional development through manufacturing	Exchange and public relations Human resource development Industry-academia-government collaboration International Small and medium-sized enterprises Environment Occupational safety and health Regional cooperation	https://www.kyokogyo.or.jp/ list of activities
	2	industry	a public interest incorporated association, KYOTO Industrial Support Organization 21	We will contribute to the development of Kyoto industry by placing the utmost importance on communication with customers, making effective use of all resources, and providing high-quality services that are truly useful for the corporate activities of small and medium-sized enterprises.	https://www.ki21.jp/aboutus/	Under the cooperation of industry, academia and public, this corporation integrates various business activities such as technological development, human resource development, market development, fund raising in various aspects such as establishment, innovation of technology and management of small and medium-sized enterprises, creation of new business. The purpose is to contribute to the promotion of Kyoto industry.	(1) Business related to support for utilizing information technology (2) Business related to technical development support (3) Business related to market development such as mediation of ordering transactions and optimization (4) Business related to management and technology consultation, research, and information collection and provision (5) Business related to support for human resource development (6) Business related to investment, debt guarantee, fund lending and equipment lending (7) Other businesses necessary to achieve the purpose of this corporation	https://www.ki21.jp/aboutus/
	3	public and industry	general incorporated association, Kyoto Chiesangyo Sozonomori	While aiming to create new value through the exchange and fusion of wisdom, we will strategically promote industrial measures and contribute to the development and revitalization of the Kyoto economy.	https://chiemori.jp/	Economic development through industrial measures	Promotion of new value creation through exchange and collaboration Strategic promotion of industrial measures Support for training industrial human resources Promotion of industry-academia-government collaboration and realization of smart society Promotion of industrial promotion, etc. in collaboration with related organizations	https://chiemori.jp/
	4	public	Otamba Tourism Promotion Committee, Seven cities and towns that straddle Kyoto and Hyogo prefectures (Fukuchiyama City, Ayabe City, Kameoka City, Nantan City, Kyotamba Town, Tamba Sasayama City, Tamba City)	Through the fascinating people of the Otamba area, which straddles Kyoto and Hyogo prefectures, we are disseminating information on Otamba's world-class culture, traditions, tourism, food, and manufacturing.	https://marugoto-daitamba.jp/%E5%A4%A7%E4%B8%B9%E6%B3%A2%E3%81%A8%E3%81%AF	6 cities and 1 town cooperate as "Otamba" to promote tourism and special products.		https://marugoto-daitamba.jp/%E3%82%B5%E3%82%A4%E3%83%88%E3%83%9E%E3%83%83%E3%83%97
	5	public	Kyoto Prefecture Northern Region Regional Cooperation Urban Area Formation Promotion Declaration (5 cities and 2 towns in Kyoto Prefecture)	Utilizing the strengths of each of the 5 cities and 2 towns, the northern part of Kyoto Prefecture will form a single economic and living area by enhancing the division of roles and functions through cooperation and cooperation, and improving the convenience of networks such as public transportation. However, we are aiming to realize a metropolitan area with 300,000 people that has a rich and cultural living environment that is not found in the urban area.	https://www.city.maizuru.kyoto.jp/shisei/cmsfiles/contents/0000003/3312/renkeibizyon.pdf	"Kyoto Prefecture Northern Region Cooperation Vision" formulated as a guideline for realizing the creation of the northern region of Kyoto Prefecture	Tourism field Industry field Emigration / settlement field Education field Administrative service field Energy field Public transport network field	https://www.city.maizuru.kyoto.jp/shisei/cmsfiles/contents/0000003/3312/renkeibizyon.pdf

Table 2-2 List of activities and measures (partial)

mainly targeted areas		Stakeholder type	organization name	base vision			List of activities / measures (candidates for R & D issues)	
				Overall policy / management philosophy	URL	Listed or inferred base vision	Targets based on the classification of regional issues T1 declining birthrate and aging society T2 Safety and security T3 Environment / Energy T4 Sustainability Guarantee comprehensive goal → Vision, Improvement of QOL items related to multiple	URL
	6	public	Kyoto Prefecture Chutan Wide Area Promotion Bureau	Regional promotion of Kyoto Prefecture and Chutan area - Areas where diverse lifestyles can be realized according to each individual's circumstances and wishes, such as "country life," "machinaka living," and "two-region living." - A region where various industries from agriculture, forestry and fisheries to manufacturing and service industries are actively carried out, and a wide range of work styles can be selected from self-employment to employment. - A sustainable area where a virtuous cycle of economic activities and community activities leads to further migration and settlement while young people are firmly established in the area and	http://www.pref.kyoto.jp/chiikishinko/koiki/index.html http://www.pref.kyoto.jp/chutan/kishin/12935199533 96.html	What we want to achieve 20 years from now (2040) is to create an area where we can enjoy both the charm of the countryside and the functions of the city, and realize the lifestyle we seek in the sea, satoyama, and town.	(1) Creating a sustainable community where "nurturing, employment, and housing" are enriched and young people want to take root (2) Expansion of exchanges and creation of related population by promoting "another Kyoto" (3) Creating a disaster-resistant area by promoting national resilience Points to note ・ Progress of globalization such as revitalization of exchanges of people, goods, information, etc. across regions and national borders ・ Progress of technological innovation (AI (artificial intelligence), ICT (information and communication technology), IoT (Internet of Things), etc.) ・ Diversification of values and lifestyles ・ Lack of human resources to support local industry, social infrastructure, and local communities and increasing importance of "mutual assistance" ・ Increase in areas where it is difficult to maintain village functions and increase in the importance of securing transportation within the area ・ Increasing number of elderly people living alone due to the arrival of the 100-year life ・ Progress of aging social capital ・ Occurrence of natural disasters (Nankai Trough	http://www.pref.kyoto.jp/shinsougoukeikaku/documents/3chiiki.pdf
wide area mainly in Northern Kansai	7	public	Kyoto Prefecture Tango Wide Area Promotion Bureau	Regional promotion of Kyoto Prefecture and Tango area - Safe and secure area Efforts to strengthen the region to respond to large-scale natural disasters are progressing, and everyone can continue to live in a healthy and lively manner with peace of mind. - Area where you can earn A "profitable area" where local industries such as tourism and manufacturing and core industries such as agriculture, forestry and fisheries are further developed and new industries are created. - Area where everyone can play an active role A "region where everyone can play an active role" who lives in Tango and is responsible for the local industry and community while each person	http://www.pref.kyoto.jp/chiikishinko/koiki/index.html http://www.pref.kyoto.jp/tango/ki-kikaku/14800003.html	The Tango area where you can continue to live in good spirits with peace of mind and realize your dreams with hope in the 20 years you want to achieve (2040).	(1) Creating a safe and secure community where people can continue to live (2) Industrial promotion by strengthening earning power (3) Securing and training human resources to support the region	http://www.pref.kyoto.jp/shinsougoukeikaku/documents/3chiiki.pdf
	8	academy	Kita Kinki Regional Cooperation Organization (Fukuchiyama Public University)	In order to contribute to the development of the Kita Kinki region, we will work based on three principles (behavior, community contribution, and risk prevention).	https://www.fukuchiyama.ac.jp/kitare/	As a "university for citizens, a university for the community, and a university that walks with the world," we will further strengthen and expand community contribution projects and community collaboration.	First, a research department will be established. Second, the Citizens' Learning Department and the Machikado Campus Department will be established. Thirdly, we will enhance the literary cooperation in regional cooperation. なお、下部組織の北近畿地域連携会議に実績ありex.高齢者の免許返納In addition, there is a track record in the Kita Kinki Regional Cooperation Conference of the subordinate organization ex.	https://www.fukuchiyama.ac.jp/kitare/img/about/policy02.pdf
	9	private	According to the Cabinet Office NPO portal site, there are 1,468 NPOs in Kyoto Prefecture.		https://www.npo-homepage.go.jp/npoportal/list?goc[]=026&goc[]=112			
	10	finance	Bank of Kyoto	"Serving the prosperity of the community" Our basic mission is to contribute to the creation of a prosperous local community and the development of local industries, and as the largest retail bank in our hometown of Kyoto, we will do our utmost to serve the local community.	https://www.kyotobank.co.jp/about/policy/index.html	The Bank of Kyoto Group will continue to grow and develop vigorously with a virtuous cycle of "improving the satisfaction of all employees" and "improving the satisfaction of the region and customers."	a) Business domain from banking to comprehensive financial solutions b) The best mix of face-to-face and digital services c) Creating a more fulfilling environment where employees can grow and play an active role d) Fostering and securing specialized human resources and diverse human resources	https://www.kyotobank.co.jp/news/data/20200323_2048.pdf

LEARNING COMMONS IMPROVEMENT PROJECT WITH A STUDENT-CENTERED APPROACH -TOWARD AN INDIVIDUAL OPTIMIZED LEARNING SPACE-

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Abstract

Many universities have Learning Commons as facilities to support students' independent learning. Most of these facilities are located in libraries and include large, open spaces for group study, presentations, and rest areas. Some commons have student TA mentors on site.

On the other hand, although our campus has a space for active learning in the library, the area is small in area, and the facility was found to be designed for only uniform use. Therefore, we planned to renovate the learning space to suit the students' learning styles. Before making specific renovation plans, we conducted a survey of all students regarding their learning styles. As a result, we found that while most of the students were individual learners, they also expressed a desire for a space where they could study in small groups.

Based on these results, students created a renovation plan, and students also designed and built the desks and chairs. The outcome of this project was not only the creation of a commons, but also a highly effective educational experience. Students who participated in this project needed to demonstrate teamwork, independence, responsibility, and discovery of challenge in order to create the learning space they wanted. As a result, they were able to create a Learning Commons optimized for the individual, even in a small space.

Keywords: *Learning Commons, Specific Optimization, Independence, Responsibility skills, Collaborative Work, Spatial Design*

Introduction

Learning commons, which can be found in various educational institutions today, originated from learning support spaces that began to be installed in some U.S. universities in the 1990s, and are characterized by the configuration of furniture and equipment that can be freely laid out according to the learning styles of users. (Beagle, 1999; Berge and Mckean, 2015) They are often provided as facilities within libraries, especially for the use of information. The role of the Learning Commons is not limited to providing a simple learning space. They also provide opportunities to develop communication skills, teamwork, independence, a sense of responsibility, and creativity through group learning. The role of the Learning Commons is also to support students' learning through cooperative activities between the library and other departments. In Japan, however, most Learning Commons are provided as self-learning spaces for students.

Many universities have Learning Commons as facilities to support students' self-learning. Most of these facilities are in libraries and include large, open spaces for group study, presentations, and rest areas. Some commons have student TA mentors on site. On the other hand, our campus, in conjunction with the renovation of the library in 2016, we have established an active learning studio (space for active learning) (ALS) in the library. However, because the library is compact compared to other libraries such as universities, the ALS has a small area of approximately 76 m^2, and the facility was designed only for classroom use and uniform usage. Therefore, although some students were using the space daily, the overall use of the space was not progressing well. Therefore, we planned to renovate the learning space to fit the learning styles of our students. We conducted a learning style survey of all students, and based on the survey results, students created a renovation plan. The students also designed and made the desks and chairs, and the renovation was student-centered project. As a result, we were able to create an individually optimized learning space in a compact space and improve student use of the space. This report provides an overview of the project and how students are using the space.

Project goals and Procedure

This project aims to establish a new Learning Commons where many students can gather and develop their creativity through independent and collaborative learning, as well as a space that enables students to learn in their preferred learning style (learning method) by renovating the existing ALS. To achieve this, we decided to proceed with the project according to the following

steps. A: Conduct a learning style survey; B: Formulate design requirements based on the survey results; C: Conduct a renovation design competition by students; D: Design detailed furniture and room layout based on the selected design; E: Furniture fabrication by students; F: Installation of original design furniture and peripheral equipment. The above procedures are described in detail in the next and subsequent chapters.

Learning style survey

To promote the project, a learning style survey was first administered to the school's students. The response rate was 69.4% (n=559/806, multiple choice). The survey asked students to select any learning environment that they preferred or would like to use for independent study. Figure 1 shows the results of the survey. Option numbers with in the Figure 1 are shown in Table 1. As Figure 1 shows, students at the school prefer relatively more individual study, and fewer students seem to choose an environment where they can work on assignments in groups.

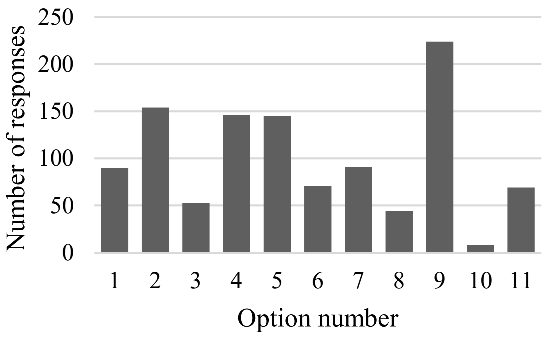

Figure 1 Students' preferred learning style in self-study

Table 1 Learning styles corresponding to the option numbers in Figure 1 and Figure 2

Op. No.	Learning style
1	Counter without partition
2	Counter with low partition
3	Large size rectangular table for 8-12 students
4	Round table for small group
5	Restraunt-style sofa seating for 4-6 students
6	Free address seating with floor cushion and small round low dining table
7	Semi-private room for a group work
8	Learning support booth
9	Completely private learning space
10	Others
11	No study space required

Figure 2 shows the results of a re-tabulation of the responses of students who prefer individual study spaces. Figure 2 shows that students who prefer individual study also need a group study environment (#4, #5). Based on these survey results, the basic concept of the new Learning Commons was to provide facilities mainly for small group study.

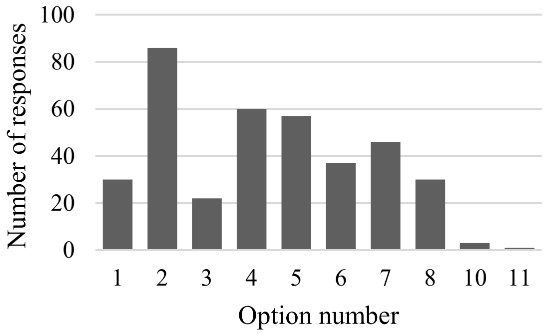

Figure 2 Learning styles selected by students who chose #9

Formulate design requirements

An initial design proposal was made based on the results of the survey. Considering the goal of the Learning Commons, the layout was designed to be suitable for group study in principle, and the individual study environment was to be provided in a separate room as a "no-chit-chat" space. The initial proposal of the new Learning Commons is shown in Figure 3.

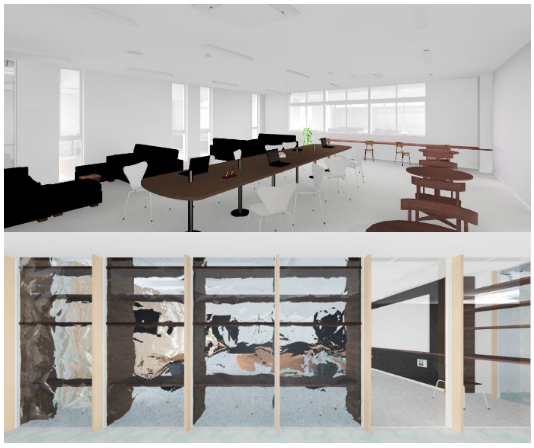

Figure 3 Initial design concept of the new Learning Commons

The original plan placed a large rectangular table with a small partition in the center of the room for large groups or individual study. The layout was designed to have small round tables and restaurant-style small study areas around the center table. Folding carrel desks were placed near the walls. In addition, a dedicated space for peer support by student mentors was also provided to create a student-centered learning environment. The window glass on the corridor side is translucent to ensure privacy for students studying in the room. In the addition, to support group study, a large whiteboard is installed on one wall.

Design competition by students

A learning commons design competition was held with second year and fourth-year students in the civil engineering course as participants. The design of many learning commons is mainly based on educational theory, with existing furniture and fixtures to create a highly sophisticated space. On the other hand, our school is small and consists of students aged between 16 and 22, so we believe that a familiar design, relaxing space, and easy-to-use furniture are the key points for many students to use. In addition, by adopting the students' own ideas, they can develop a sense of independence and responsibility, and the facility will be loved for a long time as a facility that they have created. In addition, by leaving the facility in an unfinished state, it can be linked to continuous improvement activities in the future, contributing to increased student motivation. For these reasons, it was decided that the design would be student driven. Figure 4 shows an example of a design that received a high evaluation from the students' mutual evaluation.

Figure 4 Presentation poster of highly rated design proposal

The points of high evaluation were a relaxing space with wooden furniture, a design that considered ease of use, and a café-like space that students felt familiar with. These points are important for students to use the Learning Commons continuously and independently. The proposal was also technically ambitious, including the installation of a standing space even in a small space.

Detailed design of furniture and room layouts

Based on the adopted design, the students designed the furniture to be installed. As shown in Figure 5, an engineer who works as a temple carpenter at a local company was invited as a technical advisor, and the design work was carried out mainly by the students while receiving expert advice on wooden furniture. In addition, not only students in the civil engineering course but also students from other courses participated in the lighting design and wall design.

Figure 5 Collaboration work with carpenter

Furniture production by students

For the production of the designed furniture, we visited the factory owned by our technical advisor and used specialized processing machines, as shown in Figure 6. Although our campus is equipped with many processing machines, most of them are metalworking machines, so the wood processing was done off campus.

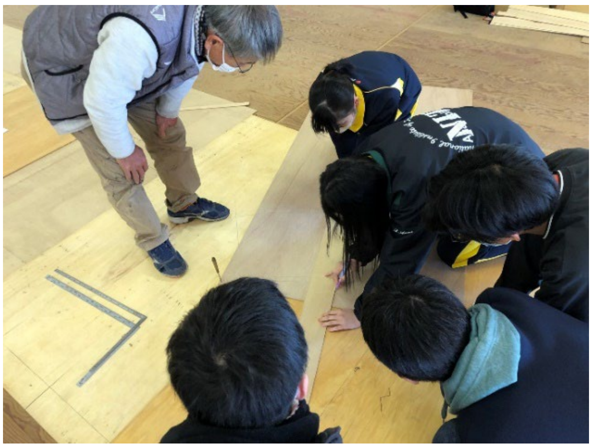

Figure 6 Furniture making work in the wood processing plant

It was a very informative and experiential learning opportunity for the students to learn about work that they do not normally experience and to see how professional technicians do it.

Learning Commons development by installing furniture and peripheral equipment

The completed furniture was brought in and installed based on the space design. Figure 7 shows the overall view of the Learning Commons after completion. The furniture is shown in Figure 8-10. Figure 8 shows the circular table that serves as the symbol of the Learning Commons. The circular table is made entirely of local wood, with 17 pieces of different types of wood combined in a radial arrangement. The radial arrangement represents the expansion of students' independent learning starting from here, and the design is intended to trigger learning by matching the number of the 17 goals of the SDGs.

Figure 7 Overall view of the new Leraning Commons

Figure 8 Circular center table

Figure 9 shows a circular bench seat placed around a circular table with eight sliding chairs, each of which has a concealed luggage compartment under the seat. The curved seating surface was difficult to make retractable, but professional advice made the design possible.

Figure 9 Circular bench seat (left: closed, right: open)

Figure 10 shows a rectangular table and bench seat arranged around the room. Although the design is simple, it was achieved with advanced techniques, including the installation of reinforcements in places that are difficult to see. These pieces of furniture were also made exclusively from local wood.

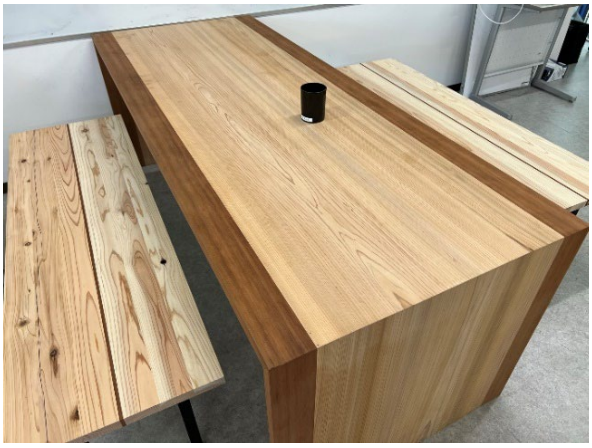

Figure 10 Rectangular table and bench seat

In addition, a large monitor as shown in Figure 11 was installed on the wall as a learning support device. Figure 12 shows the sign at the entrance, which was designed and fabricated using a laser cutting machine installed on campus.

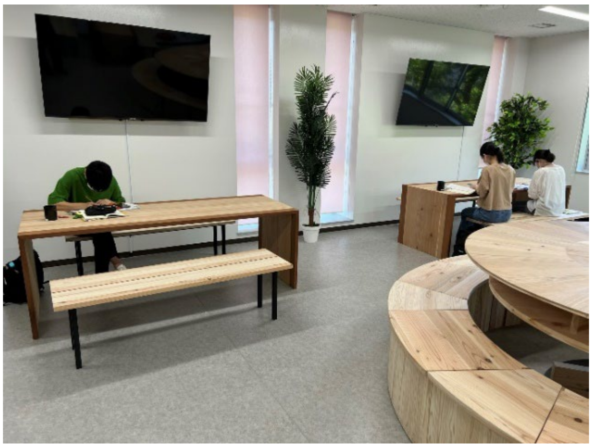

Figure 11 Wall mounted monitor

Figure 12 Sign at the entrance of Learning Commons

Use of Learning Commons

The completed Learning Commons is usually open to students as an independent study space. During a certain period before regular examinations, peer support activities are conducted using the dedicated space shown in Figure 12. Peer support activities are based on mutual teaching among students, and mentor students respond to questions from many students. In the future, we plan to promote peer support not only for study counseling, but also for life and career counseling.

Figure 12 Activity of peer support students

Conclusions

This report described the outline of the Learning Commons development project, which was carried out on the initiative of students. We analyzed the learning styles of the students and completed a space to promote individual optimized learning by creating a layout based on the results of the analysis. In addition, students were able to conduct design competitions and design and manufacture their own furniture, which enabled them to experience experiential learning based on interaction with professional engineers, which is difficult to experience in general classes. Through these efforts, the use of the new Learning Commons has been very active, and we can expect more independent learning activities in the future.

Acknowledgements

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PRACTICE AND EVALUATION OF JOINT EDUCATION PROGRAMS BETWEEN KOSEN STUDENTS AND ICT INDUSTRY

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Abstract

KOSEN Joint Education Project Team implements and supports educational projects in collaboration with companies, providing technical contests and leaning places. The main objective is to provide more students with opportunities to challenge contests and improve their skills; through the collaborative contents between KOSEN and companies, various educational programs for participating students, their achievements, and visualization mechanisms will be presented.

Starting in 2019, project teams will compete and enhance each other's originality and use of various technologies through the presentation of results in the "System Creation Contest" among technical colleges. Various devices and technologies are the learning objects of IT education, and their cross-disciplinary efforts are noticed by students. This contest takes the form of a competition in which students propose their creative ideas as a system, actually build and demonstrate it across the boundaries of technical colleges, and compete against each other. In addition, by exhibiting the systems built with the support of various companies in the same space, the contest also stimulates synergy and exchange activities among the students participating in the contest.

In this session, we will report on the technical achievements of individual participants from the viewpoints of corporate supporters and participating students. In addition, we will share and organize information useful for future joint educational events hosted by conference participants, such as changes in implementation patterns and project schedules before and after the dissemination of Covid-19.

Keywords: *Joint Education Program, Contest, Generic skill for Engineer, KOSEN, Industrial Collaboration*

Introduction

Students who apply to KOSEN (National Instate of Technology, Japan) follow a different five-year path than most high school students after completing compulsory education, and from their first year, many of them are enroll

ed in specialized departments and have a strong desire to "improve themselves" in their own way. We believe it is necessary to provide them with education that enables them to acquire useful knowledge and skills through joint education using the network of technical colleges located throughout Japan and the latest equipment used by companies.

On the other hand, the Central Council for Education's report "Toward the Construction of Bachelor's Course Education," released in 2008, has begun to focus on quality assurance in education. It states that in addition to the acquisition of academic knowledge, emphasis is being placed on cultivating the ability to utilize knowledge, creativity, and the ability to continue learning throughout one's life. The purpose of this commentary theme is to cultivate practical engineers through joint education with companies. It is not only the

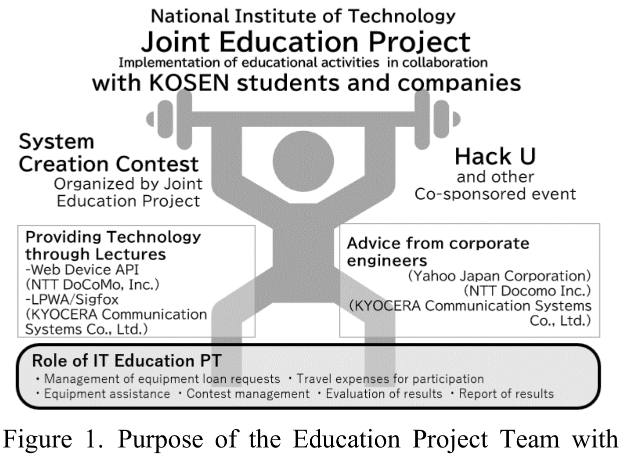

Figure 1. Purpose of the Education Project Team with major contents described in this paper

acquisition of knowledge, but also the training of the ability to realize it, which is in line with the content of the report.

Fig. 1 shows a conceptual diagram of the educational practices being undertaken in cooperation with companies. The IT Education Project Team (IT Education PT) of the National Institute of Technology Joint Education Project (Joint Education PJ) provides educational programs for students and plans and manages technical workshops for faculty members. In the Joint Education PJ, students learn advanced technologies that are difficult to handle in limited class time and produce works of art in collaboration with corporate technology and engineers who play a leading role in society. The goal of the program is to provide students with opportunities to improve their skills, and to advance and individualize the education at technical colleges by planning new IT technology education and educational programs such as contests held in cooperation with companies.

In this paper, we will describe the details of the IT Education PT's collaborative project with industry, its cooperative framework, and the results of the project. In addition, as a review, we will introduce the method used to check the growth of students based on generic skills and the cross-disciplinary abilities of the model core curriculum developed by the National Institute of Technology, and explain the effects of collaboration with companies in each program, as well as the evaluation of students and companies.

Outline of joint education program

In this section, the "Hack U" program, which was conducted by the IT Education PT and cosponsored by Yahoo Japan Corporation, a hands-on, online-style "workshop" conducted in cooperation with Kyocera Communication Systems Corporation and NTT DOCOMO, Inc. The "System Creation Contest" was held to showcase the technological results of the training sessions. An overview is given in this section and the implementation is described in the next section.

Method 1 Open Hack U

Some large and medium-sized companies have new business proposal systems and in-house venture systems, and terms such as "on-campus ventures" are beginning to become common in school-related fields as well [1]. The term "hackathon" is a generic term for events in which a specific group of people work together for a short period of time in an intensive and fun way to improve their IT skills and teamwork. It is gaining recognition as an attempt to create value from new ideas using methods different from the product development model [2].

Hack U, a hackathon event hosted by Yahoo Japan Corporation, is based on Hack Day, a development contest held by Yahoo Japan Corporation, and is held jointly with educational institutions as a manufacturing experience event for students. This event is designed for technical college students, and is easy to participate in and enjoyable for all participants in a friendly atmosphere. The event is usually held in Sendai, Tokyo, Osaka, Nagoya, Fukuoka, and other cities and educational institutions.

The Joint Education PJ participates as a co-sponsor of the event, supports the participation of many technical college students as an introduction to external contests.

Specifically, teams composed of technical college students are screened in advance to select teams recommended by the Institute of National Colleges of Technology. The selected teams will be supported by the organizer, Yahoo Japan, in the form of subsidizing part of their transportation expenses.

The judging criteria for the Hack U Grand Prize (one team at each venue) and the Excellence Award (teams that exceed a certain level at each venue) are works that demonstrate overall excellence in technology, design, and ideas, and are evaluated by the judges at each

competition. In addition, the Happy Hacking Award, an on-site voting award, will be determined by voting at the work exhibition following the presentation of works. Students with technical skills can also lead to participation in Hack Day, which brings together works from all over the country with no age limit.

Method 2 IoT / Device WebAPI workshop

One of the recent keywords in the information industry is the Internet of Things (IoT), in which various objects have communication functions and can be mutually controlled, and a wide variety of devices and services will be developed in the future [3].

Against the backdrop of this momentum, the Device WebAPI Consortium was established in 2015. Its purpose is to discuss, examine, and exchange information and opinions to promote

the spread and use of WebAPI, which makes it easier to use various devices such as IoT devices and wearable

Table 1 Technical support in system creation contests

Equipment Items Provided	Equipment Details	Source.	How to use
PLC main unit Peripheral equipment	NX1P2	OMRON Corporation (Joint Education PJ Owned)	Free of charge to teams that wish to use it.
Single Board Computer LPWA/Sigfox Communications Dedicated shield with module	Arduino Uno Una Shield or X kit	Kyocera Communication System Corporation	Provided free of charge to teams that wish to use it.
Complete Smart House Simulation Set	Smart House Dev Kit	NTT DOCOMO, INC.	Free of charge for teams that wish to use it.

Figure 2. Hack U
(a) Group photo at the face-to-face meeting
(b) HackU KOSEN 2021 online

devices connected to smartphones and other devices. The framework for WebAPI is called GotAPI (Generic Open Terminal API), which is defined by OMA (Open Mobile Alliance), a standards organization. The purpose of GotAPI is to unify interfaces for accessing a wide variety of external devices from web applications running on a web browser or native applications running on a smartphone OS.

There is no unified IoT education in the curriculum of each technical college. Therefore, the Joint Education PJ aims to develop IoT learning materials in cooperation with NTT DOCOMO and expand the learning environment through classes, extracurricular activities, and contests. Specifically, the PJ is working with engineers to create hands-on learning materials for technical colleges using robot cars and smart homes as learning materials for beginners of device WebAPI, and is providing learning opportunities in the form of delivery classes at technical colleges. From FY2019, the project has evolved into a system creation contest, described below, as an opportunity for students to continue development and showcase their achievements.

Method 3 LPWA/Sigfox workshop

The number of IoT devices is increasing every year, and various types of communication are being prepared for them. In order to cope with the arrival of the IoT era, colleges of technology need to train engineers with the knowledge to communicate sensor data obtained from devices. In this context, LPWA (Low Power Wide Area) is a power-saving long-distance communication standard that is attracting attention as a technology that can cover remote and wide areas [4].

The Joint Education PT will conduct hands-on courses using actual devices with Kyocera Communication Systems Corporation personnel as lecturers in order to learn the basics of communication using Sigfox, one of its communication technologies. Similar to NTT DOCOMO's course, the company will continue to offer the course to students who wish to

participate in the system creation contest after the course. As with NTT DOCOMO's course, a mechanism was established to allow students to continue their learning and present their results in a system creation contest.

Method 4 System Creation Contest

Starting in 2019, the Joint Education PJ hosted the System Creation Contest, which aims to compete in the use and originality of various technologies and to enhance each other among technical colleges through the presentation of results. In the previous joint education PTs, technology contests have been held by each collaborating company on a given theme, using technology designated in collaboration with individual companies. Since a wide variety of devices and technologies are subject to IT education, we thought it would be possible to bring awareness to students by learning about them across the board in the course of the project.

The contest will be based on a form of competition that transcends the boundaries of technical colleges, in which students will propose their creative ideas as systems and actually build and demonstrate them. In addition, by presenting the systems built with the support of the respective companies in the same space, synergy and exchange activities among participating students will be stimulated.

In the application process, an entry sheet is compiled at the application stage, which describes the theme and outline of the project and the concept of the system to be developed by each applicant. After that, the problems and solutions are reviewed, and teams are selected to

participate in the results presentation, where the selected teams will give a presentation of their concepts in the contest. A common theme for each division will be set each year for system proposals and development. For the first System Creation Contest in 2019, the "Control System Division" and "LPWA System Division" were established for each collaborating company. In the second contest, NTT DOCOMO participated and established the "Cloud System Division". Under the conditions specified in each division, various actuators, sensors, etc. were freely

The contest was designed to build a system that solves problems around us with innovative and novel ideas by integrating them into the Table 1 shows the support provided to the teams to participate in the System Creation

Contest. A total of 19 teams entered the third annual contest in FY2020: 4 teams in the control system category, 7 teams in the LPWA system category, and 8 teams in the cloud system category. Participating teams will receive equipment and technology from the aforementioned partner companies to make their final presentations. After the selection of project members, all teams were selected for the final presentation.

Result 1 Open Hack U

Fig 2 shows the presentations and the presentation; in the 2019 competition, a team from a technical college won the top prize in two competitions, while university teams also participated. Only the team that wins the best prize in each regional competition is invited to Hack Day, which is held in Akihabara and has no age limit. Several teams recommended by the Organization of National Colleges of Technology also participated in Hack Day. In FY2021, Hack U KOSEN 2021 was held for technical college students, including majors. This will lead to an increase in the number of participating technical college students by including students from technical colleges who do not specialize in information-related manufacturing.

The first prize was awarded to the winner of the first prize at this competition. The grand prize winner of this competition was a work that assisted technical college students in obtaining subject credits. It was a work that

was typical of technical college students, displaying necessary assignments and required scores for examinations based on data from each subject and individual grading targets.

Result 2 IoT / Device WebAPI Workshop

In 2018, courses using the robot car learning kit developed by the partner company were held as part of club activities at Kurume National Institute of Technology and other schools. In 2019, courses using smart home learning kits provided by the companies were held at Toyota National Institute of Technology and Kurume National Institute of Technology.

Fig 3(a) and (b) show the Smart Home Learning Kit. This kit is based on ARCKIT, an architectural model block, and Android Things, a platform for IoT. The kit can be expanded by adding various sensors, fans, LEDs, etc. to it. In planning the production of the kit, we considered that it would be of interest to students in fields other than mechanics and electrical electronic information engineering, for example, architecture.

Fig 3(c) shows the workshop conducted at Toyota National Institute of Technology in 2019. The participants were 24 students from the Department of Information Technology and the Computer Department, who were divided into groups of four each and facilitated by NTT DOCOMO engineers. After first learning about the basic principles and operations required for development using the IoT access control engine, the students then set their own tasks and practiced programming in their individual groups on the subject of measuring and controlling the various sensors and actuators included in the smart home kit. For example, they controlled the temperature using actuators in accordance with the actual environment, such as turning a fan under room temperature and illumination conditions. At Kurume National Institute of Technology, eight fifth-year students in the Department of Electrical and Electronic Engineering took the course, and each student used one set to practice the same content as at Toyota National Institute of Technology. In FY2020, the video materials will be linked to the 2nd System Creation Contest described in Sections 2.4 and 3.4. In FY2020, the contest was linked to the 2nd System Creation Contest described in sections 2.4 and 3.4. The study kits and video materials were loaned to the students who entered the contest, and they were able to receive advice from NTT DOCOMO engineers while producing their works and sharing their results with other participating students.

Result 3 LPWA / Sigfox Training Sessions

Fig 4 shows the LPWA / Sigfox training sessions held in 2019 with instructors from Kyocera Communication Systems at each technical college. Students were able to acquire knowledge in a lecture format, and at the same time, they were able to acquire data hands-on using a single board computer equipped with the Sigfox module shown in Fig 4 (b), and check the data on a web page.

Figure 3. Device WebAPI workshop (a) Learning kit provided by partner company (b) Smart home exterior (c) Hands-on lecture

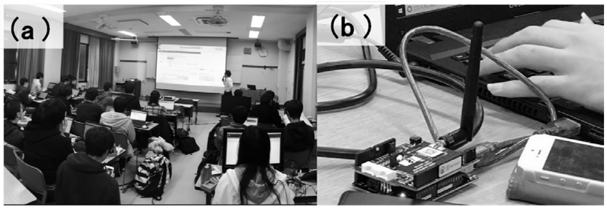

Figure 4. LPWA: Sigfox Training Course

(a) Lecture (b) Sigfox devices provided

Twenty-two students from Toba National College of Maritime Technology and 30 students from Toyota National Institute of Technology attended the course.

The Corona Disaster focused on conducting courses online, and in FY2021, the courses covered everything from basic information for beginners to case studies of applications in society. As a result, more than 100 students and faculty members participated, and the technology was able to penetrate the market. In addition, a roadmap was developed so that students could present their works created based on the knowledge gained in the lectures at the system creation contest described below.

Result 4 System Creation Contest

At the final presentation, all teams that have passed the selection process will be judged on their presentations and demonstrations by a panel of six judges, two from cooperating companies and two from the project. For the contest held in 2028, a large-scale presentation was held face-to-face at a rented venue in Tokyo, where the headquarters of the Organization of National Colleges of Technology is located.

Fig 5(a) shows a group photo of the System Creation Contest. The first contest was held in March 2019 at the Hitotsubashi Auditorium, with 89 participating students submitting works full of ideas and many that they felt would be useful.

During the judging of presentations and demonstrations, some teams made brief and humorous presentations, creating a tense yet relaxed atmosphere for the judging. In the demonstration hall, students actively asked questions to each other about their systems, and it was impressive to see many teams actively exchanging

opinions. As a result, the participating teams were able to get to know each other and achieve their initial goal.

Figures 5(b) and 5(c) show group photos of the online system creation contest. The second contest was scheduled to be held in March 2020, but many technical colleges prohibited extracurricular activities in accordance with the school closure policy, making it difficult to develop and present the results, and the final presentation was cancelled. In 2021, the third contest, the contest was held at Teams in anticipation of the impact of the coronavirus. The contest was held with a total of 10 teams and a total of more than 50 people, including judges and faculty advisors. Fortunately, no one was prohibited from entering the school premises, and the remote presentation videos and demonstrations, as well as comments from the corporate judges, allowed for interactive communication.

Although it was the first time for the event to be held remotely, the video submitted in advance by the Joint Education PJ committee members and the demonstration time on the day of the event were well-paced and well-produced.

Discussion

Fig. 6 shows the results of data collection using ICT. In the joint education PJ, achievement targets that serve as indicators of learning outcomes in line with individual characteristics for the learning areas and achievement goals of each contest are clarified, and the degree of growth is checked through self-assessment by the learners. As an indicator of achievement, we devised a method to evaluate the behavioral characteristics of individual students based on the "Model Core Curriculum" released in 2011, which indicates the quality assurance of technical college education [6].

Students can self-evaluate their level of acquisition of generic skills necessary for engineers, such as delivery

Figure 5. Group photo of the System Creation Contest (a) 1st face-to-face meeting in March 2019 (b) 3rd online presentation and demo review in March 2021 (c) Online participation

time, as shown in Fig. 6(a). In addition, by setting a learning level with respect to the technology specific to each technical contest, the achievement items are set to self-evaluate the level of mastery and proficiency of the student's technology.

ICT was used to collect the questionnaires, and a method was developed to collect the data without the time and effort of student input and tabulation. A survey form using Microsoft Office365, which can be used by technical college students, was used, and student information was automatically assigned to the survey results. As shown in Fig. 6(b), the system creation contest introduced a mechanism for extracting the characteristics of each work's evaluation points. Table 2 shows the results of the system creation contest held in March 2021.

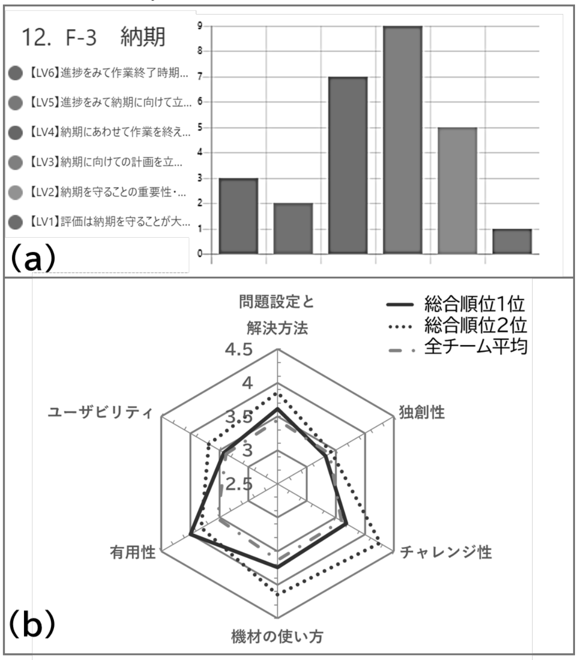

Figure 6. Example of displaying the total result using Office365Forms (a) Automatic totaling screen (b) Chart of the mutual evaluation result of works by students

Table 2 Results of the 3rd System Creation Contest

Results of Examination				award	title (of a work of art)
Overall score	Jury Results (Average)	Student peer review (average)	overall ranking		
4.60	4.00	3.63	1	Grand Prize & NTT DOCOMO Corporate Award	Mitz☆Kanjitor
4.59	3.94	3.87	2	Award of Excellence	Rubbish Terminator
4.41	3.81	3.65	3	Award of Excellence	Converting Stress in Shelters into Electricity Bicycle power generation and storage system "Charlie-kun
4.40	3.83	3.38	4	Kyocera Communication Systems Company Award	valve-net
4.31	3.69	3.68	5	AR Utilization Creation Award (equivalent to Honorable Mention)	Locker（Local Cook AR)
4.27	3.69	3.47	6	Award for the Creation of an Aging Management System (equivalent to an Honorable Mention)	Elderly watchdog device
4.14	3.53	3.65	7	Voice Industry Cooperation and Creation Award (equivalent to Honorable Mention)	Development of an emergency stop system using "voice
4.10	3.53	3.42	8	Regional Tourism Cooperation and Creation Award (equivalent to Honorable Mention)	Improvement and evaluation of remote wakasagi fishing system
4.08	3.56	3.13	9	Prize for Creation of Living Environment Measures (equivalent to an honorable mention)	Pollen cleaning system for child hay fever sufferers
3.77	3.25	3.13	10	Regional Geographic Collaboration System Creation Award (Honorable Mention)	GIScovery

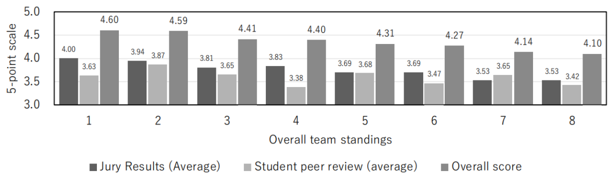

Fig 7 Results of Mutual evaluation and overall performance of students participating in the contest

As shown in Fig. 7, not only the average of the four judges from companies and technical college faculty members, but also the average of the student judging, which was a mutual evaluation of the participants, was averaged and weighted by one judge to obtain the final results.

As an example of the use of data, the radar chart shown in Fig. 6(b) illustrates the reversal of the chart size and overall ranking of student evaluations. The corporate judges focused on the social usefulness of the technology, which is a key factor in whether the students took an appropriate approach to the thematic setting. On the other hand, students tended to give high marks to how well the themed technology worked with new technologies. This is material to provide feedback for improvement for the next round.

In collaboration with NTT DOCOMO, classes were held on corporate technology, and video teaching materials were created by combining developed equipment and textbooks with video footage of the classes. The results were shared with all college leading to a ripple effect beyond the participants of the course.

The hands-on lectures conducted in collaboration with Kyocera Communication Systems, which visited each technical college, also enabled companies and students to confirm progress face to face.

On the other hand, the online courses conducted remotely in 2021 also attracted students and faculty from environmental urban planning and architecture fields other than mechanical, electrical and electronic, and information fields. By including rudimentary content with a view to attracting interest even from non-specialists, even beginning students were able to deepen their understanding of the technology possessed by the company. In addition, online lectures have reduced the barriers to implementation on the part of both the lecturers and the students and faculty members involved in the schools who attend. The seminar was considered to have ended successfully, with an increase in the number of participants despite the impact of the new coronavirus.

As a result of the production of works using IT technology and the implementation of the contest through team presentations, we will discuss three points regarding the effectiveness of the collaboration with the companies.

The first point is that "students' own desire to learn and produce results" can be drawn into action through collaboration with companies. In the creation contest, the list of members of the entry teams during the preliminary selection stage included many lower grade students, and the contest served as a gateway to technology contests. Some students have the ability to win prizes in contests where they compete on an equal footing with working professionals.

Secondly, it encourages students to grow as engineers by learning about cutting-edge technologies and considering their connection to society; AI, IoT, and telecommunications technologies are now available to the private sector in services that were not available in the past. The company provides students with guidelines on which information they should learn from in their activities, so that they can acquire information on learning methods. In addition, through the creation of socially relevant lectures and contest entries, students are able to move beyond a superficial interest in using technology to a perspective on how to build useful systems that are consistent with the theme of the project. Selecting and implementing methods that make sense to society is a necessary element in the field of engineering, where talented people are in high demand.

Finally, there is the technical operation and information acquisition at the collaborating companies. For the companies, the actual collaboration with students is also an opportunity to try out the technical materials they have created and the technical transmissions they have made. The effectiveness of courses conducted for students can be verified, improved, and incorporated into corporate activities. In addition, companies interested in cooperation with technical colleges will be involved in the contest, creating points of contact. Partner companies and the IT Education PT will continue to discuss ways to support technical college students on a yearly basis. As in the case of the Corona Disaster, where the contest was changed from face-to-face to online, a better method of publicizing and holding the contest will be discussed. The acquisition of information on school styles and student characteristics obtained during this actual work will be material in determining various activities within the company.

Summary

This report describes the events, lectures, educational materials, and system creation contests held in cooperation with Yahoo Japan, Kyocera Communication Systems, and NTT DOCOMO, and summarizes the content and results of the contests. We have also clarified the skills required by the contest and developed a system for presenting forms and charts for evaluating the skills of individual students. The development of engineers who create new value using technology is important in technical college education, and through the efforts of IT education PT, students can trace the theory they learned at the technical college to actual operation and work using actual technology and devices, together with companies. Technical college students with technical skills will not be able to have contact with society during their school years if they do not act on their own. The events and mechanisms described in this report will give students a sense of awareness and send them out into the world with a vision of life as an engineer.

We will continue to improve the level of technology by collaborating with companies and conducting technical seminars for students and faculty members of each technical college in response to technology that is evolving and diversifying every year. We would like to continue our efforts to create students with advanced and individualized technical college education, which is a major objective of the Joint Education PJ.

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DETERMINANTS OF LEARNER SATISFACTION WITH A SKILLSFUTURE SHORT COURSE ON ROBOTIC PROCESS AUTOMATION DEVELOPED USING AGILE SUCCESSIVE APPROXIMATIONS MODEL

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Abstract

With the proliferation of SkillsFuture Series of short training courses offered by tertiary institutions, measuring course quality and determining the factors impacting adult learners' course satisfaction have become increasingly important. In respond to frequent changes and timely updates on course curriculum, the use of agile Successive Approximations Method (SAM) as an instructional design model has recently received attention among adult educators because of its agility and iterative approaches. To date, there is a dearth of evaluation studies on short courses developed using SAM, and this study attempts to fill the gap in the literature. The present study aims to investigate the factors that predict course satisfaction, and examine if there are gender differences in the significant predictors. Data were collected from 131 adult learners who attended the 1-day SkillsFuture course on Robotic Process Automation in the Polytechnic using an online Course Experience Questionnaire (CEQ). CEQ comprises six factors (i.e. good teaching, clear goals and standards, appropriate workload, appropriate assessment, generic skills and course satisfaction), measured on a 5-point Likert scale. Preliminary analysis showed that the reliability of the six CEQ variables measured using Cronbach alphas ranged between 0.72 and 0.93, above the recommended threshold of 0.70. Hierarchical regression analysis showed that appropriate assessment and generic skills were two significant predictors of course satisfaction. The regression model explained 60% of the variance in course satisfaction, of which generic skills accounted for 3% of the variance. Appropriate assessment was the significant predictor of course satisfaction among males whereas generic skills and good teaching were significant predictors of course satisfaction among females. The contribution of this study is two-fold. First, the study contributed to our knowledge about teaching quality of a short course developed using SAM. Second, the study findings highlighted the need to re-examine the roles of appropriate assessments and developing generic skills efficacy among adult learners in information technology training. Finally, implications for practice, study limitations and directions for future research will be discussed in the paper.

Keywords: *Satisfaction, SkillsFuture, Robotic Automation Process, Agile, Successive Approximations Model*

Introduction

The rapid advancements in digital technologies is disrupting global economies and industries at an unprecedented rate, changing the nature of work, jobs and employment. To steer through these uncertainties and challenges, Singapore has identified lifelong learning through a transformation of its educational systems and policies to prepare for a diverse and future-ready workforce that is equipped with not only in-demand skills but also agile, innovative and globally competitive (Committee on the Future Economy, 2017).

The SkillsFuture initiative implemented in 2016 is a "national movement national movement to provide Singaporeans with the opportunities to develop their fullest potential throughout life, regardless of their starting points" (SkillsFuture Singapore, 2021a). SkillsFuture Singapore provides a repertoire of training programmes and funded schemes to encourage people in the workforce to undertake continual upskilling and reskilling to keep up with the industry changes and unforeseen technological advances. Targeting at Singaporeans who are keen to acquire basic understanding or deepening their skills, the SkillsFuture Series is an array of curated short industry-relevant training courses focusing on eight priority and emerging skills, including tech-enabled services, digital media and advanced manufacturing to name a few (SkillsFuture Singapore, 2021b).

With the growth in the number of companies sending their staff to attend the SkillsFuture Series training courses across multiple runs, it is imperative that training providers adopt an agile and responsive instructional design system to incorporate stakeholders' feedback in developing new training courses, and adept at making changes and improvements to the curriculum within short lead time before conducting the next run of the course. A thorough review of literature showed there is limited research on evaluating short training courses developed using an agile methodology. Therefore, the aim of this

present study is to investigate adult learners' perceptions of the various factors impacting their overall satisfaction with a Skillsfuture short course on Robotic Automation Process (RPA) developed using an agile Successive Approximation Model (SAM), and examine if there are gender differences in the predictors impacting overall course satisfaction.

Literature Review

Agile Successive Approximation Model (SAM)

Despite the popularity of ADDIE, critics argued that ADDIE is too rigid and not designed to handle rapidly changing curriculum requirements (Adnan & Rizhaupt, 2017; Allen 2017; Brown & Green, 2015). To address ADDIE's shortcomings, Allen and Sites (2012) developed a Successive Approximations Model (SAM) with the aim of providing increased flexibility with agile development, speed, responsiveness and collaborative opportunities for stakeholders to work together to generate a more effective and efficient solution. SAM utilizes a more iterative process that focuses on prototyping, and assumes that stakeholders will change their minds during the project (Jung et al., 2019). Hence, the need to quickly update the changes at each stage of the project through an iterative process by incorporating stakeholders' feedback is crucial.

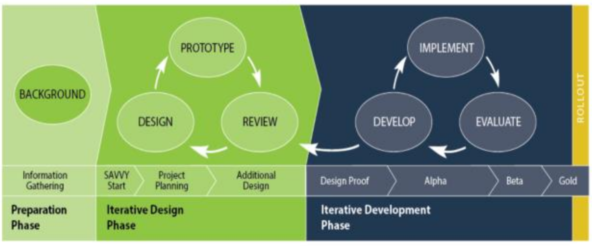

Figure 1. Three phases of SAM

Figure 1 shows the three phases of SAM, i.e. preparation, iterative design and iterative development (Allen Interactions, 2022). SAM starts with the preparation phase where the project team gathers information and background knowledge relevant to the project. In the iterative design phase, the "SAVY Start" serves as a kick-off meeting where the project team will review the collected information, and generate initial ideas through brainstorming and initiate the prototyping. The initial prototype will be rotated through a cycle of review-design-protype to ensure the creation of a right product. In the last iterative development phase, the project team will be involved in the develop-implement-evaluate cycle where the design proof is presented and tested, followed by the release of the alpha, beta versions, and finally rolling out the gold version of the product.

Course Experience Questionnaire (CEQ)

CEQ was originally developed with the aim of capturing students' evaluation of teaching effectiveness as a performance indicator of the quality of university teaching (Ramsden, 1991). Over the years, various versions of CEQ have been developed, and the most common is the 25-item CEQ version comprising 5 subscales including (a) good teaching, (b) generic skills, (c) clear goals and standards, (d) appropriate workload and (e) appropriate assessment, and a single item measuring overall satisfaction with the quality of the course (McInnis et al., 2001). Grace et al. (2012)'s extended version of CEQ comprising 6 subscales, with an additional 5-item course satisfaction subscale. According to Thien and Ong (2016), the conceptualization of each CEQ subscale is as follows:

a) Good teaching – nature of teaching experienced during the course
b) Generic skills – enhancement of selected generic skills
c) Clear goals and standards – clarity and meaningfulness of the course structure
d) Appropriate workload – level of workload that hinder deep learning
e) Appropriate assessment – level of assessment that promote deep learning
f) Overall satisfaction – overall satisfaction of course quality

Measuring Course Experience Quality and Satisfaction using CEQ

The literature is well documented with a plethora of studies using CEQ, albeit with mixed findings depending on types of academic courses, universities and countries. A study conducted by Ginns et al. (2007) found that appropriate assessment, appropriate workload, and provision of clear goals and standards were important determinants of university students' overall satisfaction in Australia. Grace et al. (2012) reported that good teaching, generic skills, and clear goals and standards had significant positive effects on business degree students' course satisfaction in an Australian University. However, appropriate workload and appropriate assessment had no significant positive effect on students' overall satisfaction (Grace et al., 2012). Another study conducted by Yin and Wang (2015) found that clear goals and standards, and generic skills were significant predictors of Chinese undergraduates' overall satisfaction. In a more recent study conducted by Thien and Jamil (2020) in a university in Malaysia, it was reported that good teaching, clear goals and standards, appropriate workload and appropriate assessment were significant predictors of students' overall satisfaction. In an earlier study, Ramsden (1991) found that inappropriate workload and inappropriate assessment were positively related to the surface approach to learning.

In testing a conceptual model using structural equation modeling, Grace et al. (2012) found that generic skills had the highest, significant and positive direct

effect on course satisfaction compared with the other CEQ predictor variables (GT, CG, AA and AW). This indicated that generic skills played a pivotal role in affecting overall course satisfaction. The key role of generic skills is further exemplified when comparison is made between male and female students.

Regarding gender differences, the literature has consistently provided evidence of significant differences between male and female students on various CEQ factors as predictors of course satisfaction in higher education. Grace et al. (2012) found that good teaching, generic skills, and clear goals and standards have significant positive effects on course satisfaction among males whereas only generic skills had significant positive effect on course satisfaction among females. In another study conducted by Thien and Jamil (2020), good teaching was the strongest predictor of overall satisfaction for female students. In contrast, there was no significant effect of good teaching on overall satisfaction with male students.

Aims of study and research questions

This study aimed to investigate adult learners' course experience and their overall satisfaction with a 1-day SkillsFuture short course developed using SAM. In particular, the study examined the factors predicting course satisfaction, and if gender differences exist in the predictive relationships.

The following research questions were formulated to guide the data analysis (see Figure 1 for the research model):

1) To what extent do the CEQ factors (i.e. good teaching, clear goals and standards, appropriate workload and appropriate assessment) predict course satisfaction?
2) To what extent does generic skills explain course satisfaction above and beyond what is already explained by the other CEQ factors (i.e. good teaching, clear goals and standards, appropriate workload and appropriate assessment)?
3) Are there gender differences in the extent to which CEQ variables (i.e. good teaching, clear goals and standards, appropriate workload, appropriate assessment and generic skills) predict course satisfaction?

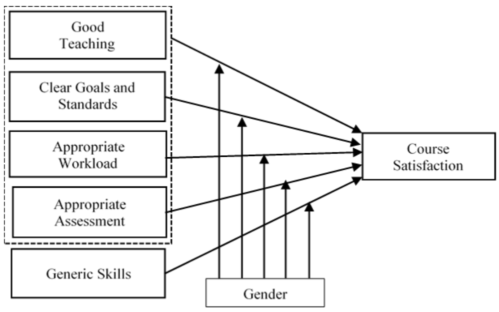

Figure 1. The research model

Method

The study employed a cross-sectional quantitative survey method. Convenience sampling procedure was selected in this study. The sample consisted of 131 adult learners who attended the 1-day SkillsFuture short course on '*Experience How Robotic Process Automation Makes Your Work Easier*' conducted by staff from the School of Engineering and School of Infocom in the Polytechnic. Participants completed an online questionnaire at the end of the course, and they have been informed that participation in the study was entirely voluntary and their responses will be kept strictly confidential. Ethics approval has been sought from the Polytechnic In-house Ethics Review Committee where the study was undertaken.

The sample comprises 59 (45%) participants were females and 72 (55%) were males. 19.1% were in the age range between 21-30 years, 32.8% between 31-40 years, 31.3% between 41-50 years, 13.0% between 51-60 years, and 3.8% were 61 years and above. The median years of working experience among the participants was between 11-15 years.

The 21-item Course Experience Questionnaire (CEQ) was adapted from a study conducted by Grace et al. (2012). CEQ comprises six factors or subscales, i.e. good teaching (6 items), generic skills (3 items), clear goals and standards (3 items), appropriate workload (3 items), appropriate assessment (3 items) and course satisfaction (3 items). All the items were rated on a 5-point Likert scale, ranging from '1 = strongly disagree' to '5 = strongly agree'.

Results

Measurement model assessment

Confirmatory Factor Analysis (CFA) was employed to estimate the quality of the factor structure and underlying factor loadings by statistically testing the fit between the proposed measurement model and data (Yang, 2005). According to Hair et al. (2010), a variety of goodness-of-fit indices is recommended to assess the model fit. The goodness-of-fit indices used in this study included Chi-square (χ^2), Root Mean Square Error of Approximation (RMSEA), Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), and Standardized Root Mean Square Residual (SRMR). The results of the CFA on the measurement model showed an acceptable fit to the data (χ^2 [173] = 324.66, $p<.001$; χ^2/df = 1.88; RMSEA = .08; CFI = .94; TLI= .92; and SRMR = .04) based on the recommended threshold values for fit indices by Hu and Bentler (1999) and Kline (2005). All standardized factor loadings were above .45.

Descriptive statistics, correlations and reliabilities

The mean, standard deviations, correlations and reliabilities of the six study variables were presented in Table 1. The mean ratings of the study variables ranged

between 3.98 and 4.24, with moderate spread around the mean (.50 ≤ SD ≤.59). Reliability of all the study variables measured using Cronbach's alpha were positive, range between .72 and .93, all above the threshold value of .70 (Nunnally & Bernstein, 1994). It is noteworthy that good teaching had the highest and significant correlation with generic skills (β=.68, p<.01), and appropriate assessment had the highest significant relationship with course satisfaction (β=.69, p<.01). All the 5 variables (GT, GS, AW, AA and GS) had significant and positive relationships with course satisfaction (.53≤ r ≤.69, p<.01).

Table 1. Descriptive statistics, correlations and reliabilities

Variables	*M*	*SD*	Bivariate Correlations					
			1	2	3	4	5	6
1. Good teaching (GT)	4.13	0.59	(.93)					
2. Clear goals and standards (CG)	4.08	0.55	.75**	(.92)				
3. Appropriate workload (AW)	4.18	0.59	.73**	.71**	(.87)			
4. Appropriate assessment (AA)	4.07	0.50	.51**	.49**	.52**	(.72)		
5. Generic skills (GS)	3.98	0.56	.68**	.59**	.60**	.58**	(.87)	
6. Course satisfaction (CS)	4.24	0.55	.60**	.53**	.60**	.69**	.67**	(.93)

Numbers in parentheses diagonally indicated reliability of variables, ***p* <.01

Hierarchical multiple regression analysis

To answer research question 1 and 2, we employed the hierarchical regression analysis which is a robust statistical technique widely used to assess the unique effects of the predictors on the dependent variable by specifying the order in which the predictors need to be processed in the regression analysis. To run the hierarchical multiple regression analysis, we entered course satisfaction as the dependent variable, and two blocks of predictor variables entered as dependent variables (see Table 2 below). In Model 1, a first block of four dependent variables comprising good teaching, clear goals and standards, appropriate workload and appropriate assessment were entered, followed by second block comprising generic skills in Model 2.

Table 2. Hierarchical multiple regression results for course satisfaction

	Dependent variable = course satisfaction			
	Model 1		Model 2	
Predictor variables	Std *β*	*t*-value	Std *β*	*t*-value
1. Good teaching	.24	2.45*	.13	1.29
2. Clear goals and standards	-.02	-.16	-.04	-.38
3. Appropriate workload	.18.49	1.96	.15	1.70
4. Appropriate assessment	.49	6.98***	.41	5.77***
5. Generic skills			.27	3.25**
F-value	43.52		39.55	
Adjusted R^2	.57		.60	
ΔR^2	-		.03	

Note: **p* < .05; ***p* < .01, ***p<.001

To answer research question 1, the results of the first model of hierarchical multiple regression showed that appropriate assessment (β = .49, p<.001) was the strongest and significant predictor of course satisfaction, followed by good teaching (β = .24, p<.05). Overall, Model 1 with four predictor variables explained 57% of the variance in course satisfaction with F(4, 126) =43.52, p<.001.

To answer research question 2, we examined the result in Model 2, after entering generic skills in the second block of the hierarchical multiple regression. Appropriate assessment (β=.41, p<.001), followed by generic skills (β = .27, p<.01) turned out to be positive and significant predictors of course satisfaction. The addition of generic skills accounted for an additional 3% of the variance in course satisfaction. Overall, Model 2 has an effect size of 1.58, considered large according to Cohen (1988)'s guidelines. No multicollinearity issues were detected as the variance inflation factor (VIF) values ranged between 1.45 and 3.23, were significantly lower than the threshold of 10.0 (Hair et al., 2010).

To answer research question 3, hierarchical multiple linear regression was conducted using course satisfaction as the dependent variable and the 5 CEQ factors as predictor variables separately for the males and females, and we compared the results. Appropriate assessment (β=.57, p<.001) was a positive and significant predictor of course satisfaction for the males, whereas good teaching (β=.29, p<.05) and generic skills (β=.28, p<.05) were significant predictors of course satisfaction for females. The five predictor variables accounted for 62% and 64% of the variance in course satisfaction among the males and females respectively.

Table 3. Hierarchical multiple regression results for course satisfaction by gender

	Dependent variable = course satisfaction			
	Males (N=72)		Females (N=59)	
Predictor variables	Std *β*	*t*-value	Std *β*	*t*-value
1. Good teaching	.20	1.06	.29	2.42*
2. Clear goals and standards	-.15	-.87	.14	1.38
3. Appropriate workload	.13	1.12	.22	1.64
4. Appropriate assessment	.57	5.75***	.07	.65
5. Generic skills	.16	1.25	.28	2.63*
F-value	24.28		21.83	
R^2	.65		.67	
Adjusted R^2	.62		.64	

Note: **p* < .05; ***p* < .01, ***p<.001

Discussion

The dearth of studies related to adult learners' experience with SkillsFuture short courses and their overall satisfaction has motivated the present study to investigate the factors that affect course satisfaction and examine if gender differences exist in these predictive relationships. The present study has revealed several important findings worthy of discussion.

First, generic skills had the lowest mean rating among all study variables, and this variable had the highest significant and positive relationship with good teaching. One plausible explanation is that participants may find that the 1-day RPA training course inadequate for the acquisition of generic skills, i.e. analytical skills, problem-solving skills, and confidence to handle

unfamiliar problems. Therefore, the participants could perceive good teaching to play a critical role in helping them acquire these generic skills.

Second, appropriate assessment and generic skills were significant positive predictor of course satisfaction in the overall group. This finding is consistent with studies conducted by Grace et al. (2012) and Thien and Jamil (2020). In the context of this study, the use of appropriate assessment, including both formative and summative, could potentially promote participants' deep learning strategies and motives (Yin et al., 2014), associated with applying the above-mentioned generic skills to complete their learning tasks. Hence, lecturers are encouraged to facilitate and conduct appropriate feedback with assessment tools to evaluate participants' attainment of learning outcomes in the course. The adoption of SAM instructional model also aided the lecturers to conduct frequent post-run iterative revisions to the learning material and instructional strategies based on learners' feedback and in-class observations and this could have a direct impact on how learners learn and apply the concepts in subsequent runs of the course.

Third, appropriate assessment was a significant predictor of course satisfaction for male participants, whereas good teaching and generic skills were significant predictors of course satisfaction for the female participants. Studies have shown that compared to male students, female students are more likely to conform and be conscientious (Chapman, 1996), have less self-confidence (Sadler-Smith, 1986), more anxious and exhibit failure anxiety (Osborne, 2001). Hence, it is plausible that female participants in this study tended to focus more on good teaching as this will help them overcome learning difficulties, and develop generic skills "efficacy" to complete learning tasks. On the other hand, Yin et al. (2014) found that male students were more actively and deeply engaged in their learning compared to female students. Hence, given that male participants may have more self-confidence than their counterparts, they tend to focus more on the importance of assessment as a determinant of course satisfaction, as it provides feedback for them to ensure accuracy and completion of the learning tasks.

Limitations and future research

This study is not without limitations. First, the participants in this study were adult learners undertaking a particular SkillsFuture short course within a polytechnic. Hence, we caution generalizing the results to the whole population of adult learners in the polytechnic. Future study could include a bigger representative sample from various short courses offered by different schools in the Polytechnic. Second, the study employed convenience sampling and we cannot rule out the possibility of a selection bias where those who participated may have differed in their attitudes and motivations compared to non-participants. Hence, the use of stratified random sampling should be considered in future study. Third, the five CEQ factors accounted for 60% of the variance in course satisfaction, leaving 40% unexplained. Future studies could consider including other predictor variables such as learning approaches (deep versus surface learning) and learning support which could improve the predictive power of the research model.

Conclusions

This study has contributed and extended our knowledge of assessing teaching quality of short courses in the polytechnic by identifying the impact of course experience quality factors on adult learners' overall satisfaction with a SkillsFuture short course. Specifically, the study findings highlighted the need to re-examine the roles of appropriate assessments and developing generic skills efficacy among adult learners in information technology training. There is potential of using SAM as an agile and responsive instructional model, and CEQ to collect useful feedback on teaching quality of short courses. Finally, this study serves as a baseline for adult educators, particularly those who are developing short courses in other disciplines using SAM, to facilitate benchmarking for teaching practices within the Polytechnic.

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FACILITATING PRE-CLASS ACTIVITIES WITH ARTICULATE STORYLINE 360 IN FLIPPED LEARNING

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Abstract

Student engagement is a commonly cited challenge when facilitating pre-class activities in flipped learning. The students tend to neglect pre-class learning, deterred by the perception that it causes an increase in workload. This causes the students to be ill-prepared for subsequent in-class learning activities impacting on their learning (Yang, 2021). A few key recommendations from a previous systematic review to promote student engagement in pre-class learning included segmenting the lecture content into 15-30 minute bite-sized segments, and incorporating quizzes with immediate formative feedback for students' self-evaluation on understanding (Yang, 2021).

These recommendations were taken into consideration when designing the pre-class learning on Articulate Storyline 360 platform during the curriculum transformation of a module on anterior ocular diseases. The possible interactivity options within Articulate Storyline 360 further promotes student engagement in the course of attempting the quizzes.

This paper explores the students' feedback on their experience in the pre-class learning with Articulate Storyline 360, incorporating key recommendations on promoting student engagement. The feedback was collected through a Google Form for students to input after every pre-class learning on Articulate Storyline 360. The learner experience was generally positively rated, citing the quizzes as useful for the students' learning. The lesson objectives listed clearly at the beginning of the lesson further helped the students to manage expectations. Majority of the students were able to complete the pre-class learning without technical difficulties, and those who were unable to managed to seek help from the lecturer smoothly through the backchannel using MS Teams. Students commented positively on the engaging animations and interactivities within the design, either on the narrated lecture content or self-evaluation quizzes. There were also suggestions to improve the learner experience further by removing distracting elements, for example music played during the quiz.

Overall, the feedback was positive on the student engagement in pre-class learning incorporating key recommendations in the design of Articulate Storyline 360 platform as a digital learning tool. Apart from affirming the effectiveness of the recommendations, there were also learning points from students' feedback on specific elements that may backfire and distract students from learning when incorporated in the design.

Keywords: *Student engagement, flipped learning, pre-class learning, Articulate Storyline 360*

Introduction

Flipped learning utilises the blend of pre-class self-directed asynchronous learning in which the content covered is then further deepened though active and collaborative learning in in-class activities (Akçayır & Akçayır, 2018). The learner accesses the content in the asynchronous learning at own time, pace, and space, completing quizzes to facilitate self-assessment of understanding. The learner then comes to the classroom equipped with the relevant knowledge to further deepen it through active and collaborative activities with their peers. However, student engagement is a commonly cited challenge when it comes to pre-class activities, with students failing to complete the learning as designed before the in-class segment. This is a cause for concern as students may not then have the necessary knowledge to participate meaningfully in the in-class activities, which may compromise their own and their peers' learning especially in activities where collaboration is needed (W. He, Holton, Farkas, & Warschauer, 2016).

Thus, the need to address the lack of engagement in pre-class activities in a flipped learning experience is paramount. A previous systematic review in looking at promoting student engagement in pre-class learning activities stated key areas to look into for increasing engagement, namely technological, pedagogical, and student perceptions (Yang, 2021). This led to a series of recommendations in designing the pre-class component to increase students' engagement to complete the learning and preparation for the subsequent in-class learning. These recommendations were taken into consideration during the curriculum transformation of a module into flipped learning on anterior ocular diseases in Diploma in Optometry. Articulate Storyline 360

platform was chosen to incorporate the relevant recommendations in the asynchronous pre-class learning. It is a platform that allows the creation of an interactive e-learning course, allowing the building of a variety of interactivity with different widgets and options.

For each chapter that the students embarked on in the module, there will be two hours allocated for the asynchronous pre-class learning and 1 hour for synchronous tutorial to deepen the understanding of knowledge. The students will access the Articulate Storyline 360 platform for the pre-class learning, focusing on the content heavy knowledge of signs, symptoms, and management of the various anterior ocular diseases.

This paper explores the students' feedback on their experience in pre-class learning with Articulate Storyline 360, with the design of the platform incorporating key recommendations on promoting student engagement.

Materials and Methods

In the module curriculum transformation process, it is important to ensure that content is present in a manner that would motivate students to work through a large amount of technical knowledge at their own time and pace prior to the synchronous classroom session. One of the key challenges in the development of the online asynchronous package was the tremendous amount of content that went into each chapter, as it covers content on the anterior ocular diseases based on the anatomical structures of the eye and in each disease, signs, symptoms and management..

Cognisant of the challenges of a content heavy module, the learning designers and teaching team leverage on the key recommendations in the systematic review when thinking of the design of pre-class learning. They are:

(1) Interactive Design
Articulate Storyline 360 was the chosen platform for the learning design, due to its potential for the interactivity components. This could allow the flexibility in designing the self-assessments later.

(2) Chunking of content
In the key recommendations, it was mentioned to tap onto the duration of 15-30-min for self-directed bite-sized asynchronous learning to allow the capturing of the maximal attention span of the learner (Yang, 2021). Therefore, the content was looked into to provide the chunking of each chapter into bite-sized topics appropriately to not lose the flow of the lesson, particularly in the context of working with pre-recorded lectures. The consideration would be to chunk the narration and infuse it into the design on the Articulate Storyline 360 platform appropriately, so that the chunking would not appear too abrupt for the learning, and yet provided the motivation in completing the topics to encourage and engage the students in completion.

Interactive tabs (Appendix A) were incorporated to indicate different key learning points. This allows the selection of critical information and narration to be categorised. The content is classified into different tabs which chunks content into bite-size knowledge for students. This also helped the students to interact visually with the content to be better engaged at a more controlled pace of learning.

(3) Quiz & Test
Quizzes (Appendix B) with formative feedback for students' self-assessment of understanding (Yang, 2021) were incorporated into Articulate Storyline 360 learning package. This gave students an avenue to immediately understand their areas of strengths and weaknesses regarding the content they have learnt earlier, and to have the awareness to bridge the necessary gaps before the in-class segment. A variety of interactive quizzes were set up for this, using the suite of interactive widgets provided by the Articulate Storyline 360 platform, like sorting task, matching, hotspots etc. The interactivity allowed for stronger engagement with the quizzes. Students were provided with the option for multiple attempts, so that they can try the quizzes again to reinforce their learning. Formative feedback was provided for students to bridge their learning gaps.

Google feedback forms were administered to the students to collect their sentiments in the asynchronous learning experience. The questions in the feedback form included looking at the specificity of the lesson objectives, satisfaction with the learning experience, and usefulness of the formative quizzes. It consisted of questions on a Likert scale and short answer questions for students to indicate their feedback.

Results and Discussion

A total of 447 responses was gathered from 76 Year 1 students in the Diploma in Optometry course, as the students were invited to provide their feedback for four chapters with 11 bite-sized topics. 92.5% of the responses agreed and strongly agreed that the Articulate Storyline 360 lesson has clearly specified the lesson objectives and topics. The learning objectives listed right at the beginning provided students with clear understanding on what they were learning in the chapter. The intent was to

help them to better understand the context of learning to promote learning engagement.

90.7% of the responses were satisfied and extremely satisfied with the pre-class lesson's experience. This was further complemented by open-ended feedback asking on what the students liked about their learning experience. The students had the option to revisit the content if more time was needed, or to proceed if they already had prior knowledge or strong familiarity with the topic with the help of the menu bar. If the students would like to reattempt the formative quizzes within the Articulate Storyline 360 platform, they would be able to use the menu to help them navigate too. The students appreciated the design of this feature, commenting in the section on the open-ended feedback that it allowed them the ease of navigation within the platform, which added a positive element to the learning experience.

The students also commented that the chunking of information made it easier to understand and digest. There was also a significant number of comments referring to the structuring of the content within the platform. The students appreciated the use of interactive tabs for them to click on, to reveal further information and clinical photos for their reference, particularly on technical terms that may need more explanation for clarity. The grouping of information according to ocular conditions or signs was also appreciated for helping the students to study in a more organised manner, and to take in relevant information in the same tab or slide. Students also commented that the use of animations added to the interactive elements in the learning process, increasing the positivity of the learning experience. Most importantly, the organisation led to the perception of manageability, as visually the information is less cluttered since most information is hidden within the tabs, ~~since~~ as students' perception of workload is one of the deterring factors in students' motivation when it comes to pre-class learning (W. He et al., 2016).

91.5% of the responses agreed and strongly agreed that the formative quiz(zes) in the pre-class lesson were useful for their learning. This was further complemented by positive open-ended feedback from the students indicating what they appreciated about the quizzes. They commented that the formative quizzes allowed them to apply what they have learnt and reinforced their learning. Not only were the comments on the meaningful contributions to the students in strengthening their understanding on what they have just learnt, there were comments on that the quizzes were fun to attempt. This further affirms that the utilisation of a series of widgets to create different interactive experiences helped to improve the student engagement in the learning experience itself. This was also supported by a comment that the interactivity within the quiz was appreciated, instead of the usual multiple-choice questions type of quizzes. Formative quizzes form one of the key elements to engage the students in pre-class learning (Yang, 2021). Not only did they allow the students to understand how well they have learnt the knowledge, the learning analytics from the quizzes also allowed the lecturer to track the understanding and completion statistics of the students. This helped the lecturer to understand the different profiles of the students when they attended the in-class learning segment, helping to facilitate the levelling of the students' knowledge in order for meaningful participation within the classroom activities. Intentional efforts were made to address concepts that were more challenging based on learning analytics, and students were grouped based on their academic inclination and level of engagement in pre-class activities to provide heterogenous groupings for facilitating peer learning. The immediate feedback provided within the formative quizzes also helped the students to close the gaps in their understanding, further strengthening the self-directed learning in the process.

Students Suggestions: Areas to review

Students were asked to provide suggestions ~~to~~ improve the pre-class learning experience within the Articulate Storyline 360 platform. While many of the suggestions focused on the user experience of the learning package, these were areas that may cause unintended "hinderance" to students' learning progress. The comments included the concern on finding the right interactive tab to click on in order for the necessary information to be presented. This highlighted a consideration that in the course of improving the learning engagement through better interactivity, it is also important to pay attention to providing clear instructions to the students on how to interact with the tabs to reveal the necessary content. One major concern was that students might miss certain info hidden within the tabs if they did not read the instructions on how to interact with the tabs. This omission may slow down the student's learning progression and thus engagement, as there will be an obstacle on finding out how to proceed with the lesson.

There was also a suggestion for the menu bar to not only list the content of the topic, but also to indicate the duration it takes to complete that particular content. This may help the students to pace their learning better, especially in an asynchronous learning environment where they have the autonomy to decide on how they will like to segment their learning in order to better pace it. The duration can help the students to visualise the length of time to commit to their learning in order to complete the necessary pre-class learning before the in-class segment, thus better motivating the students. Besides time duration, students can also take a quiz to check their understanding to decide if they still need to go through the content.

There were also comments to include more formative quiz questions on heavier content within the topic, so that when the students had attempted the questions, they

would have reviewed the majority of the topic as well. This points to a recognition that the formative quizzes are useful for students in reinforcing on the knowledge that they have learnt, and consideration can be given to proportional quantity of questions based on the amount of content that the students have covered prior. This may allow the students a second chance in reviewing the content.

Some narrated content was created with text to speech software and there were many comments indicating that it was not effective in helping with the understanding since the tone was monotonous and some of the pronunciation could not be heard clearly. Furthermore, the lack of an option of slower playback speed did not help the students to hear the words at a slower pace to better comprehend it. This indicates the importance of warmth and interaction of a human voice when narration is required to better engage the students in learning. There should also be a consideration if an option to allow the students to do a slower playback of narration may be useful to help students to understand the narrated content, especially if the student is not a native speaker of the language in the content. Subtitles may also be useful for the students.

Interestingly, the open-ended feedback on the use of background music for the formative quizzes indicated two different perspectives. On one hand, students commented that they liked the background music while they were attempting the quiz as it provided a nice complement, while on the other hand, students commented that the music was distracting and even increased the anxiety level for some. This provided a learning point to consider students' subjectivity when designing the learning experience, particularly on elements such as music which may open up to a wide myraid of preferences and associated feelings. Putting in subjective elements may backfire on learner's engagement instead of improving it as intended. An option may be provided for students to have it or without depending on preference when incorporating these elements.

Conclusions

Key recommendations on engaging the students in pre-class learning were incorporated in the design of the asynchronous pre-class learning within flipped learning for an Optometry module on anterior ocular diseases. The learning design utilised the interactive design options within the Articulate Storyline 360 platform, and these were heavily used in the organisation of the content as well as in designing formative quizzes for the students.

Based on the feedback gathered from 447 responses from 76 students, the students appreciated the incorporation of the key recommendations, which included chunking the content to allow better paced learning. The inclusion of a menu bar to allow the students to navigate within the topic, allowing for ease of moving forward and backwards gave students a chance to revisit or forward content easily for more effective learning. The interactivity presented in the organisation of the content allowed students to be more engaged in the learning process, and also the perception of better manageability of workload which helped in motivating the students to complete the learning. The formative quizzes helped the students to reinforce their learning, and the interactivity designed within the quizzes further helped in student engagement in the process of self-assessing their understanding of the knowledge that they had learnt.

Instructions to help the students cope with the interactivity designed within the organisation of the content was appreciated, to smooth out the process in accessing the necessary information when embarking on the asynchronous learning. Clearer indication of the duration needed within the content was one of the suggestions by the students, in order to help them better pace their learning. More formative questions could be considered for content that were heavier, so as to help students with reviewing the content while attempting the quizzes to reinforce the knowledge and understanding. A human voice was preferred over text to speech in narration, to increase the engagement level of students. A slower playback speed or subtitles may be useful in helping the students to understand the narrated content. In employing subjective elements to engage the students, such as music, possible different perceptions of the elements might backfire instead of engaging the students as intended. This will have to be factored into consideration when deciding whether to incorporate subjective elements within the design of learning experience, and an option for students' choice to have it or without is to be provided.

Based on the feedback from the students, it can be concluded that designing the online asynchronous package according to the recommendations from literature did have a positive impact on students learning. While there were still suggestions for improvement on user experiences, the key objective of improving students' learning experience has been achieved.

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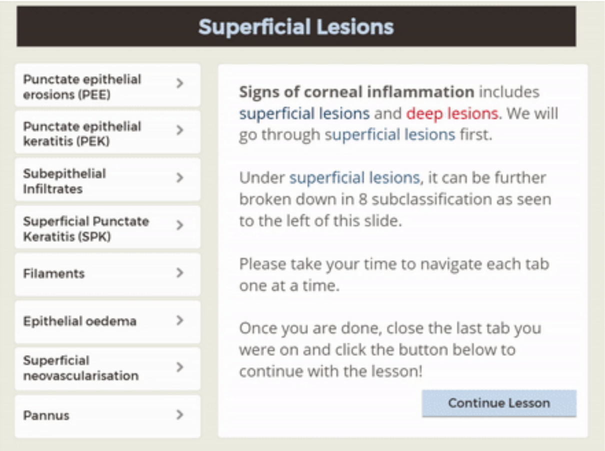
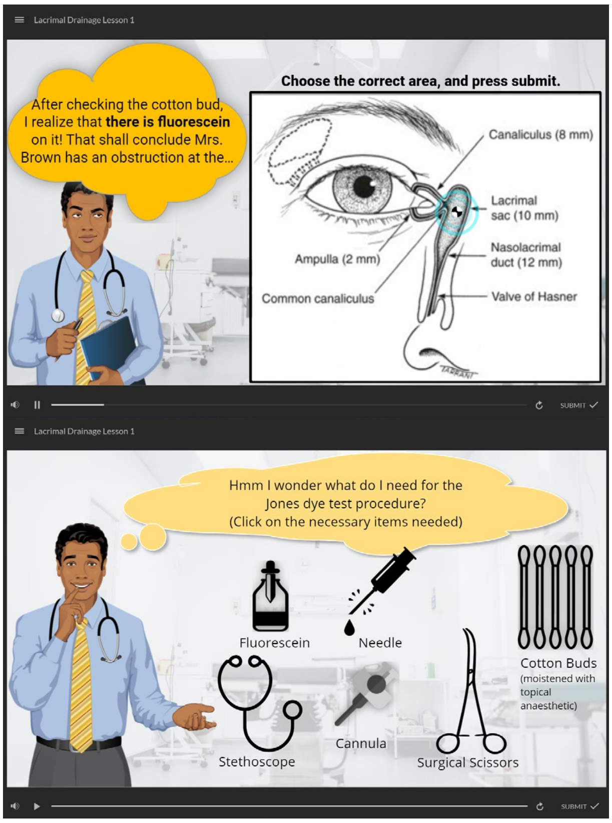
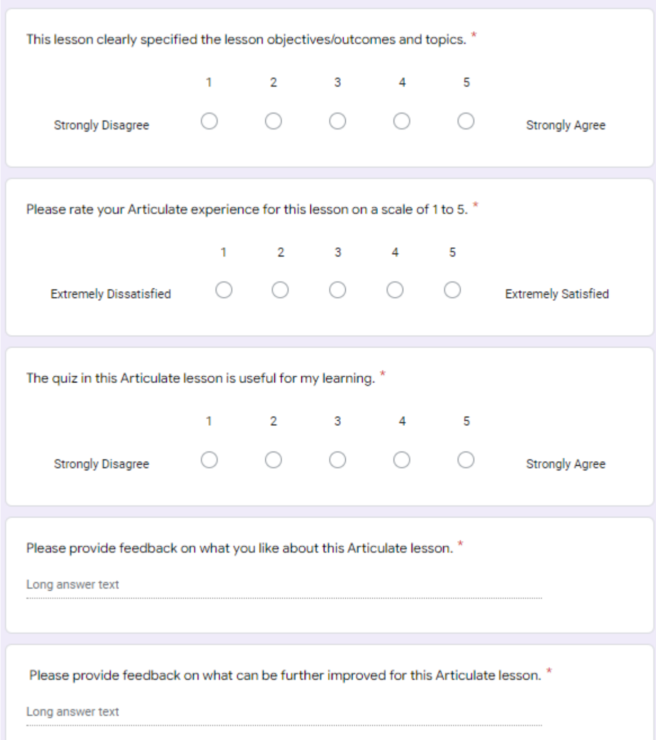
Appendix A



Appendix B



Appendix C



A Local Contribution to English Class through Distance Education under the COVID-19: Examining the Educational Effect on the Online English Conversation Classes for Local Junior High School Students

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Abstract

This paper provides the implementation of Distance English classes for junior high schools, and their educational effects. When the COVID-19 began to affect our daily lives largely, National Institute of Technology, Akita College (NIT, Akita College) has started providing technical and human resource assistance for junior high schools in Akita prefecture since the academic year of 2020. COVID-19 prevented the junior high schools from conducting English classes with ALTs and international exchange events due to people's restrictions on the movement. Under such circumstances, we have assisted local junior high schools in the aspects of technology and human resources in implementing distance classes. As for human resources, international students at our school collaborated with us and participated in the classes. During two academic years, we have offered several contents on the online English conversation classes for local junior high school students, which are supported by students from abroad. The contents include mini-quizzes on home countries of international students; grammar quizzes; presentations on school events at both junior high schools and NIT, Akita college; discussion on the international concerns, and so forth. This program is aimed at evoking junior high school students' mindsets that communicating in English is enjoyable. We also hope that it induces more interests and concerns over foreign countries in their minds. According to the results of the surveys given to the participating junior high school students, almost all students believe that their English speaking abilities improved and their interest in learning about foreign countries rose. Furthermore, most students desire to continue the program in the next academic year. The data strongly reveals a new way of contributing locally to English classes through distance education, namely an online English conversation program between local junior high school students and students from abroad.

Keywords: *Local Contribution, Distance Education, Online English Class, Technical Support on Online Classes, Local Junior High Schools*

Introduction

National Institutes of Technology (NIT) stipulates in the Act that "NIT shall offer public lectures and provide other learning opportunities for non-students (translation by authors)." Along the line, NIT, Akita College (2020) formulated the "Basic Policy on Community Contribution" and clarified one of its goals as follows; "the school will send its faculty and staff to various local committees and contribute to the local community through the provision of its human educational resources."

At the time, the global spread of the Covid-19 had a major impact on educational activities. The national and local governments issued a series of requests to refrain from face-to-face classes and outings. Educational institutions were forced to cope with the situation.

Kamikoani Junior High School (JHS) in Akita Prefecture, in past years, had worked a so-called "English Camp", a two-day and one-night cross-cultural experience through English conversation with ALTs in the prefecture. However, due to the epidemic, the school had to cancel the overnight stay and plan an online program.

Meanwhile, NIT, Akita College had set up a distance education program and was preparing for remote classes, when we heard about the camp, and decided to support the project, hoping to contribute to the local community by remote class assistance. To date, a total of ten support activities have been provided to three junior high schools: Kamikoani, Takanosu, and Ani, which are located in underpopulated areas in the prefecture.

Hyodo (2021) is a leading example of online international exchange activities at NIT, and our activity is a new attempt in that it includes contributions to the local community. See also Inoue (2022), Soyama (2021), and Tsukamoto (2022) for more information on distance learning in English at the college. The following is a report on the activities we have implemented so far and their effects.

Kamikoani 2020:1st Support

The details of the first remote education support are shown in Table 1, and the photos of the day in picture 1 and 2, respectively.

Table 1: English Camp in Kamikoani 2020

	The 1st Support
Date	July 22, 2020
Time	13:05-15:45
Location	Kamikoani JHS
Target	All students at Kamikoani JHS: 7 first-year students, 10 second-year students, and 16 third-year students
ALTs	1 in Oga City (from South Korea) 1 in Ogata Village (from the U.S.) 2 in Odate City (from South Africa and New Zealand)
Overseas Students at NIT, Akita	1 each from Mongolia, Burundi, Vietnam, and Cambodia
Equipment	Wi-Fi router, TV monitor, Tablet, Web camera, Portable speaker, for each classroom
Application	Microsoft Teams

Picture 1: Kamikoani JHS students

Picture 2: Overseas student at NIT, Akita

On the day of the camp, three teachers from NIT, Akita went to the JHS to provide support for the online system. The English Camp started in the afternoon, and seven first-year students, ten second-year students, and 16 third-year students took online English classes with four ALTs in their classrooms. To avoid overcrowding the classrooms, the students were divided into four groups: seven first-year students, ten second-year students, and two groups of eight third-year students, each in a separate classroom. The classes consisted of three class periods of 30 to 45 minutes per session, with the junior high school students exchanging with the ALTs in the first two online sessions and with the international students in the third session. The exchanges included introducing their home countries and regions, and asking questions in response. When the JHS students asked questions about famous foods and sightseeing spots in their home countries, the foreign students enthusiastically explained their countries, and they asked the JHS students some questions about their daily school life, deepening mutual exchange through English conversation.

2nd Support

After the first support, students at Kamikoani JHS responded to a questionnaire in which they expressed their desire to meet the international students in person next time. The international students at NIT, Akita, also made similar requests. In order to realize the requests, we decided to ask the international students to participate in English classes at the JHS. The details of the second support are shown in Table 2, and picture 3.

Table 2: English Class Support (International Exchange)

	The 2nd Support
Date	November 26, 2020
Time	13:25-14:20 (third-year) 14:30-15:20 (first and second-year)
Location	Kamikoani JHS
Target	All students at Kamikoani JHS: 7 first-year students, 10 second-year students, and 16 third-year students
Overseas Students at NIT, Akita	1 each from Mongolia, Burundi, Cambodia, and Malaysia
Equipment	TV monitor, Tablet, Portable speaker, for each classroom
Application	Microsoft PowerPoint

Picture 3: JHS students and Overseas student

Note that this was during the period when the second wave of the Covid-19 was just about to subside, and as indicated in the table, the number of students in this school itself was small and each group consisted of four to five students, so the program was conducted under sufficient measures against infectious diseases.

In the first-year class, the JHS students answered English quizzes prepared by the international students, and in the second-year class, students took turns asking each other questions about their own countries. Third-year students gave presentations to the international students on what they had learned from their textbooks and shared their thoughts in English. In response, the international students made comments based on the situation and position of their own countries, deepening mutual international understanding. During the classes, all students tried to communicate with one another in English to help them better understand the current domestic situation, culture, and customs in a variety of countries.

3rd Support

The third support was provided remotely under the influence of the third wave of Covid-19, as shown in Table 3.

Table 3: Remote Class Support (International Exchange)

	The 3rd Support
Date	March 3, 2021
Time	11:35-12:25 (third-year) 13:40-14:30 (second-year) 14:40-15:30 (first-year)
Location	Kamikoani JHS
Target	All students at Kamikoani JHS: 7 first-year students, 10 second-year students, and 16 third-year students
Overseas Students at NIT, Akita	1 each from Mongolia, Burundi, Cambodia, and Vietnam, and 2 from Malaysia
Equipment	Wi-Fi router, TV monitor, Tablet, Web camera, Portable speaker, for each classroom
Application	Microsoft Teams and PowerPoint

Kikuta and Muta (2001) suggest that the high responsiveness of students to ALTs and teachers (cf. Yamamoto 1993) in English conversation learning has a positive effect on learning effectiveness. Furthermore, they point out that individual communication and the enjoyment of the activity motivate students to be engaged in class, and therefore, they recommend using English games and other activities. Following the line, in the third support, we divided each class into two parts, with the first half of the class introducing an English game to build up the students' conversational response, and the second half implementing a discussion in which each student was expected to express his or her own opinion. Table 4 and picture 4 show examples of the English game, and Table 5 shows the activities for expressing personal opinions (TOPIC TALK ACTIVITY).

Table 4: Topics of English Games (1st Half)

First-year	Group 1: Present Progressive Form Group 2: Past Tense Group 3: Wh-question
Second-year	Group 1: Conjunction Group 2: To-infinitive Group 3: Comparative Degree
Third-year	Group 1: Present Perfect Tense Group 2: Relative Pronoun Group 3: Participle

Picture 4: An Example of Quizzes (1st-year Group 2)

Table 5: Topics of TOPIC TALK ACTIVITY (2nd Half)

First-year	Any new challenges you have taken on this past year, and your goals for the coming Academic year.
Second-year	Where you would like to go abroad and why, and what you would like to do in the future.
Third-year	If you were to work abroad, what other skills you would need in addition to language skills.

In the first half, a game was played to see how well the students could respond to questions from the international students in two minutes, and to build up their skills to respond to English conversation. In addition, a game was set up to test the comprehension of different grammatical items in each of the three groups,

in order to follow the content of the class as closely as possible.

Expansion of Class Support in 2021

As shown above, in the 2020 academic year, a total of three English class support activities were conducted at Kamikoani JHS. In the following year, this support was expanded from one to three schools, bringing the total number of remote class support activities to seven. The two new schools, Ani and Takanosu JHS, are located in Kita-Akita City (in the northern part of the prefecture), a depopulated area adjacent to Kamikoani Village, so the issues faced by the three schools under the disaster were just the same. All class support activities conducted during the academic year are roughly summarized in Table 6.

Table 6: Remote Class Support in the 2021 Academic Year

Dates	Names of JHS	Number of students (Grade)	Activities
①21/9/16	Takanosu	120 (1)	Quizzes and Self-introduction
②21/10/8	Ani	15 (1・2)	Quizzes and Self-introduction
③21/10/15	Ani	9 (3)	Presentation about Akita
④21/10/28	Ani	10 (1)	Presentation about school life
⑤21/12/16	Kamikoani	30 (All)	English Grammar Quizzes
⑥22/2/25	Takanosu	120 (1)	Presentation about Goals of Next Year
⑦22/3/2	**Ani**	**9 (3)**	**Learning English Debate**

During the year, due to the increase in the number of infected people, a state of emergency was temporarily declared for up to 21 prefectures. Therefore, all class support was provided remotely. The contents were based on the previous year's classes at Kamikoani JHS, but were partly revised to make them more enjoyable for the students and encourage their active participation.

Of special note was the fourth English class support at Ani JHS, shown in ⑦ of Table 6. This was held for third-year students with the purpose of "learning how to debate using English." This was made possible by active encouragement from Ani JHS side. The scene of activity is given in picture 5.

Picture 5: Debate Scene

In the class, the students were divided into three groups: for, against, and judges, and debated on the topic of "Japan is a good country to live in." Our international students listened to the arguments for and against each side, and together with the JHS students who acted as judges, took on the role of deciding which argument was superior. The following is an example of the opinions in favor and against, as well as a part of the materials on the judgments made by the international students.

Table 7: An example of opinions from JHS students and judgement from international students

<Proponents' opinion>

Japan has four seasons and we can enjoy seasonal events such as cherry blossoms, fireworks, and red leaves without spending money. Thanks to four seasons, we also have a great variety of ingredients from nature that led to traditional Japanese food culture. You can enjoy beautiful, healthy, delicious Japanese food.

<Opponents' opinion>

Japan is one of the countries that have earthquakes the most. It is not safe to live in Japan.

[Judgment sheet of Students from Abroad]

Mr. Student 1 (Proponent team won):
The proponent team had very good reason to protect their opinions. And they had very strong reason when they answered the questions from the opponent team. The opponent team could give the reason to protect their opinions, but it was not strong enough.

Mr. Student 2 (Opponent team won):
The opponent team had stronger and specific arguments. They gave examples and specific data like numbers. The proponent team's arguments were general, not unique to Japan. For example, some other countries also have four seasons, not only Japan.

The JHS students' arguments were more persuasive and heated than expected, and the international students seemed to have had considerable difficulty in making their final judgment.

Statistical Results on Questionnaire

This section mainly focuses on the statistical results on questionnaire given by students who participated in the programs at Kamikoani, Takanosu, and Ani JHSs. The results will provide answers to the following two questions; (1) whether online program attracted JHS students, and (2) if online English conversation classes have improved their speaking abilities of English and their interests in abroad. Notice that the results consist of the data based on the answers of 152 JHS students who participated in the program twice or more in an academic year. The data on the students who joined this program only once is omitted.

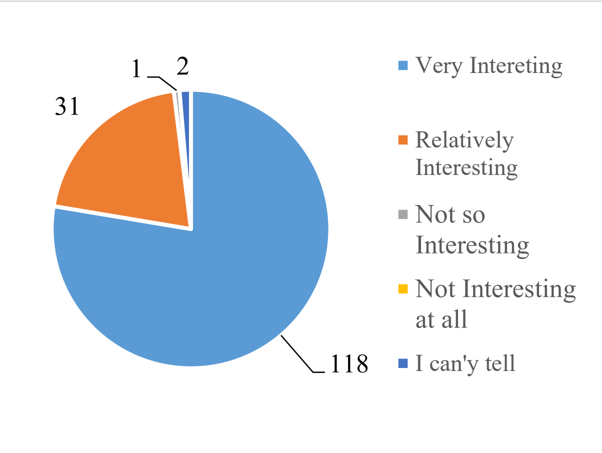

Figure 1: The Statistical Result on the Question *What do you impress about participating in Online English Conversastion Program?*

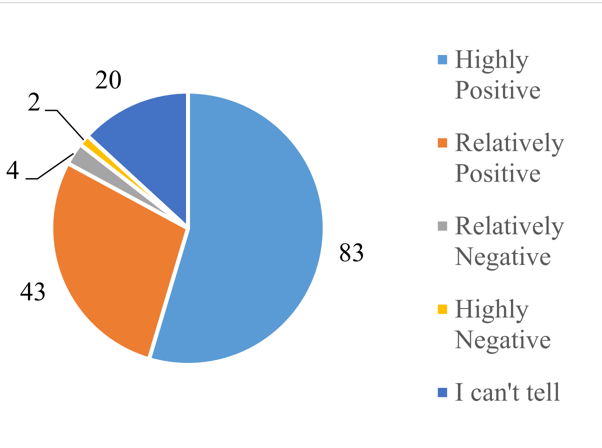

Figure 2: The Statistical Result on the Question *Do you want to take part in the program again in the next academic year?*

Let us look at Figure 1 and 2, which give a key to the answer to the first question: whether the online English conversation program attracted JHS students. The five-point scale is employed in this result: highly positive (very interesting), relatively positive (relatively interesting), relatively negative (not so interesting), highly negative (not interesting at all), and I can't tell. Note that, in Figure 1, no student selects " not interesting at all" as an answer to the question *What do you impress about participating in Online English Conversastion Program?* so that a reader cannot find the number of the students who chose the item in the pie chart.

According to the result in Figure 1, the rate of the answers *very interesting* or *relatively interesting* occupy 98% of all respondents. As in Figure 2, the rate of highly or relatively positive answers to the question is 83%. The results strongly show that our online English conversation program is enjoyable for most JHS students. The relatively high rate of the answer *I can't tell* in Figure 2 dues to the fact that the respondents include the third-year JHS students: they will graduate from junior high school in the academic year.

We also received positive feedback to the second question, which is whether the online English conversation classes could help improve the students' English speaking skills and increase their interest in learning about other countries.

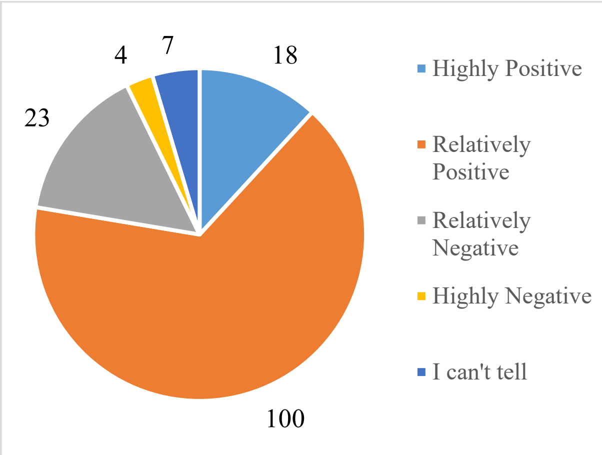

Figure 3: The Statistical Result on the Question *Do you feel the improvement of your communication skills in English by joining the programs twice?*

The staggering statistical result is provided: approximately three-quarters of the students feel their improvements in English conversation skills through communicating with students from abroad enrolled at NIT, Akita college. This means this program makes a significant contribution to improving the English conversation skills of JHS students. As for the students who answered relatively negative or highly negative statements, their responses stem from their hating of English. This implies that our program is not attractive to JHS students who dislike English. In this regard, the online English conversation program needs further improvement.

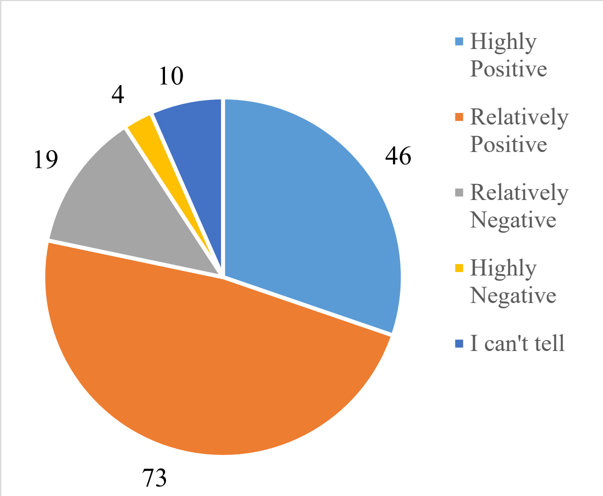

Figure 4: The Statistical Result on the Question *Has this program increased your interest in going abroad and interacting with people from other countries?*

Next is concerned with Figure 4, which represents the answers to the question *Has this program increased your interest in going abroad and interacting with people from other countries?* The figure reveals that about 75% of the students respond with highly or relatively positive answers. The result tells us that our offering program contributes to the rise of the number of the students who have positive impressions of going overseas or interacting with people from abroad.

Conclusion

In this paper, we provided examples of distance English classes for junior high schools and their educational effect. After looking at these programs in detail, we saw that most of the students who participated in the program believed in improving their speaking abilities. Furthermore, through the program, they seemed to be more interested in interacting with people from other countries.

The most fascinating point of the program is that a chance to communicate with people from abroad in English can be given to JHS students, whether they live in a city or a local area. We hope that the program will play a role in planting the seeds of international perspectives and diverse values for participating local JHS students.

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We would like to express our sincere gratitude and appreciation to teaching staffs of English in KAMIKOANI, TAKANOSU, and ANI junior high schools: SHINOHARA Hatoko, CUNNINGHAM Owen, HOANG Michael; Ashley Naoko FAGAN, Dane Curtis LAFONTE; KOBAYASHI Makiko, and Edgardo Jose SANCHEZ MENDEZ, who collaborate and support us to implement the programs.

We also wish to acknowledge YOSHIDA Jun, the former principal at KAMIKOANI Junior High School; SAKURAI Makiko, the former teaching staff at TAKANOSU Junior High School; and the board of education at KAMIKOANI village, who made essential contributions to start and continue the program. Without their sincere support, we would not have started this program.

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A NEW CROSS-LANGUAGE APPROACH FOR FOSTERING COMMUNICATION SKILLS IN ENGINEERS

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Abstract

In recent years, students who are proficient in specialized subjects and possess excellent communication skills have been in high demand at institutes of technology. Therefore, a new language education program called "Communication Literacy I" (CLI) has been implemented at the National Institute of Technology, Oyama College (Oyama Kosen), Japan. This program consists of cross-language education in Japanese and English.

Learning by making connections between their native language and a foreign language enables students to gain better "language awareness" and actively engage in linguistic activities with a greater sense of curiosity. This program emphasizes the comparison of languages and cultures. Furthermore, it is conducted by a collaborative team of nine linguistic teachers who specialize in either Japanese or English. They can apply the insights gained in this class to their own teaching practices. Thus, the CLI program also serves as a faculty development training course and has proven beneficial to both students and faculty.

In this study, approximately 200 students from first year participated in the survey to determine their level of enthusiasm and interest in regarding linguistic activities. Moreover, we surveyed the kind of insights they gained into words and thought process associated with them. The results confirmed that studying two languages with a comparative approach was effective in improving one's understanding of both languages and enhancing the ability to express oneself in a synergistic manner. Thus, this study contributes to the literature demonstrating the satisfactory effectiveness of the cross-language education program in fostering communication skills (reading, listening, writing, and speaking) among students studying at the National Institute of Technology in Japan.

Communication skills have proven to be an essential tool for engineers. This study introduced an innovative approach to language education in which students learn by making connections between Japanese, their native language, and English, the lingua franca of technical fields.

Keywords: *cross-language education, Japanese, English, communication, four skills, language activities, awareness, comparison*

1. Introduction

Colleges of technology (KOSEN) are institutions for higher education. Like high schools, those who have graduated from middle school are eligible to enroll. Once enrolled, students attend them for five years in total. With a well-balanced curriculum of general and technical subjects, the students can acquire a rich education and the systematic expertise required to become technicians. Students who graduate from this program are required to be ready to begin working on-site as technicians immediately after graduation.

Future-oriented human resources who are expected to play a significant role in today's global society and will shape the upcoming Society 5.0 (Keidanren 2022) will not only require knowledge of scientific technology, but also excellent communication and teamwork skills. It is particularly important to have the ability to communicate logically, which is also one of the abilities required by companies in Society 5.0. Communication skills are considered an essential tool not only for engineers, but for all of us in society.

It is important to nurture human resources who can present Japan's point of view to the world. Additionally, it is becoming critical for educational institutions to provide training to improve communication skills. In other words, other than technical skills in technical subjects, it is very important for students at technical colleges to acquire broader communication skills and an understanding of various cultures. They should be encouraged to nurture and express comprehensive language abilities that are not limited to their own native language. To overcome differences regarding personal values and characteristics, it is important to make a comparison and then convey one's thoughts logically to the other party in an easy-to-understand manner.

2. Theory and Implementation

2-1 General Remarks

2-1-1 Originality

Oyama Kosen introduced "Communication Literacy I" (CLI) in 2019 as part of a new curriculum to enhance students' communication skills.

Essentially, CLI is a cross-language educational program in which Japanese as a native language and English as a foreign language are taught in relation to each other. In the conventional Japanese educational system, even though they apply the same language education techniques, Japanese (the national language) and English education have been conducted within completely separate frameworks. In the pursuit of a new kind of expressive educational program, it is a challenge for CLI to transcend this framework. A unique feature of CLI is that Japanese and English teachers teach in a collaborative manner using "Japanese" and "English" as materials. In contrast to high school education, education at KOSEN is not restricted by the national guidelines, a characteristic that makes this type of education possible.

2-1-2 Methods

The course consists of 15 lessons, making it a half-year course for first-year students. Various language activities were conducted that aim to further improve the four language skills in both Japanese and English. A collaborative team of nine Japanese and English teachers continuously and meticulously held 40 meetings (August 2018–June 2022) in an omnibus format. The course format consisted of two types of class, one for all 200 students conducted simultaneously and the other of the 40 students who were preparing for debates and presentations. However, due to the coronavirus pandemic, the classes for the 2020-2021 academic years were conducted online via Microsoft Teams.

This course had two objectives:

1. To gain language awareness through by relating one's mother tongue to a foreign language as a part of the study, as well as by piquing curiosity through proactive language activities.
2. To enable students to communicate logically and smoothly by accurately understanding other people's opinions (reading and listening) as well as conveying one's own opinions (writing and speaking) in both Japanese and English.

To ensure successful learning in joint English and Japanese studies, we prepared two verticals – Comparative and OREO (Opinion, Reason, Example, Opinion). CLI consists of four sections (A–D). In Sections A and C, the students used the comparative method to gain a better understanding of the linguistic and cultural differences between Japanese and English. In Sections B and D, the students were able to express themselves more precisely by using the OREO method (Endo 2020).

The course was constructed in such a way that the number of units of language in each section gradually increases to aid students' language comprehension. Section A deals with words and sentences, Section B with paragraphs, and Sections C and D with longer passages.

The syllabus for the second semester of CLI in 2021 is presented in Table 1. The evaluations are based on regular examinations (60%) and presentations and other submissions (40%).

Table 1: Syllabus for CLI second semester of 2021

Communication Literacy Ⅰ 2021.10-2022.2			
Sections		Week	Contents
Orientation		1	Introduction /Comparison of Vowels and Consonats in Japanese and English Word
A	Language Comparison	2	Parts of Speech in Japanese Word Order in Japanese Sentence Sentence
		3	Parts of Speech in English Sentence Types in English
B	Logical Writing	4	Demonstrative Pronouns and Conjunctions in English Paragraph
		5	Demonstrative Pronouns and Conjunctions in English Logical Thinking in Japanese -Concrete and Abstract
		6	Logical Thinking in Japanese -Comparison and Analogy **Opinion** and **Reason/Example** (Support)
C	Culture Comparison	7	Reading in English: *Washoku* -Japanese Food Culture Longer Passages
		8	Reading in English: *Washoku* Reading in Japanese: *Mizu no Tozai* (Cultural Difference between East and West in how "water" is apprehended)
		9	Reading in Japanese: *Mizu no Tozai* Group Activity (to Encourage Students to Find Differences between Eastern and Western Cultures)
		10	Making a Poster for a Presentation on the difference betwen East and West
		11	Presentation
D	Logical Debate	12	Learning How to Debate Logically and Effectively Logical Thinking in English -**"OREO"** (Opinion-Reason-Example-Opinion)
		13	Preparation for Japanese Debate with **"OREO"**
		14	Japanese Debate Matches
		15	Review for Japanese Debate Matches Experience a rudimentary English debate
Summary			Review for CL Ⅰ and Explanation about Term-end Exam
Term-end Exam			

2-2 Detailed Discussion: Comparison between English and Japanese – Shift from recognition of their differences to having interest in them –

2-2-1 Practical Example 1: Language Comparison

Section A discusses students' perceptions of language differences between Japanese and English. First, we show them a Japanese part-of-speech classification table and ask them to confirm that its theory does not appear to be directly applicable through English.

The English language has five sentence patterns based on which English sentences are composed. The verb comes immediately after the subject, and the speaker can convey his/her message to the listener at an earlier stage in the sentence.

Although Japanese also has its own sentence patterns, they fundamentally differ from those of English in terms of word order. The predicate comes at the end in Japanese sentences, which indicates that it is not until there that the listener knows exactly what the speaker insists (Fujiwara 1982).

From the viewpoint above, Section A encourages students to improve their acquisition of both languages by making them aware of potential differences.

2-2-2 Practice Example 2: Culture Comparison

The theme of Section C is culture comparison. As the world is moving towards globalization, cultural clashes between nations and ethnic groups have increased. One must be able to compare the culture of one's own country with that of other countries, recognizing the characteristics of each, deepening mutual understanding. The goal of this class, is to help students develop an understanding of the perspective and method of cultural comparison, including that of language, and to teach them the necessity of having self-awareness of their own culture.

First, the students are taught how to form logical arguments through reading Japanese and English texts with a binary opposition structure, then they organize and explain the differences between Japanese and Western cultures with binary opposition in a group poster presentation.

In the first half of Section C, students learn about Japanese food and how to form logical arguments using discourse markers. Next, they read an essay from an English newspaper on urban and rural life and learn how to form arguments with binary opposition. Furthermore, they examine the differences between Japanese and English from the perspectives of high and low context, focusing on the language and conversation they use in their everyday lives and using binary opposition to examine the different ways assertions are developed in debates.

This is followed by the reading of a critical essay by Masakazu Yamazaki (2018) titled *Mizu no Tozai.* The essay compares traditional Japanese bamboo water fountains with Western fountains from various perspectives and seeks to discover the characteristics of both Eastern and Western cultures in each.

Based on this reading comprehension, students gave group presentations. Students were instructed to form groups of four and create a 790mm×1090mm poster comparing the cultures. The poster was titled "Eastern and Western OO" by comparing things from the East and West using cultural differences as an axis and identifying different characteristics of each culture, particularly Japanese culture. After creating their posters, each class of 40 students was asked to give a five-minute presentation in front of the class.

Figure 1: Presentation class 12.2021.

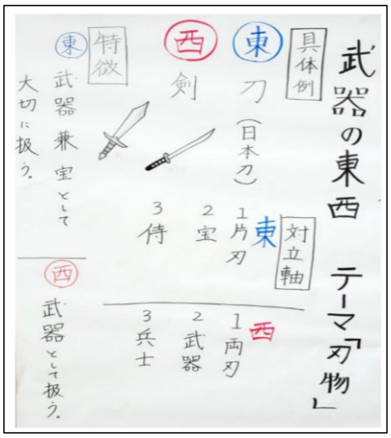

Figure 2: Presentation poster 12.2021.

2-3 Detailed Discussion: OREO

2-3-1 Practice Example 3: Logical Writing

Section B discusses logical writing as a form of written expression. When sentences are connected with an intention to form paragraphs, logic is born. However, if the logic is not structured in a methodical manner, it will not be understood by others, and its communicative effect will be lost. Therefore, it is important to communicate logically in written expression.

Generally, logical thinking refers to producing a single correct answer by applying "deductive reasoning," like solving mathematical formulas. Logical thinking allows a person to convey a message by linking two things together logically, such as *cause and effect, opinion and reason*, or *premise and conclusion*. As a

result, the listening party can gain a deeper understanding of what the speaker is saying, leading to smoother communication and stronger persuasion.

During the first half of Section B, the students were taught how to use several important expressions of conjunctions and demonstrative pronouns to create appropriate English sentences. Additionally, we conducted a lesson to introduce students to context (logical arguments) through questions based on rearranging words in the correct order.

In the second half of Section B, we explained and practiced logical thinking using Japanese sentences. Fundamental concepts of logic, *concrete and abstract* and *assertion and evidence* were covered. In *concrete and abstract*, the former refers to making abstract expressions more detailed by giving concrete examples, whereas the latter refers to summarizing concrete matters in an abstract form. *Assertion and evidence* refer to the concept that any assertion stating one's opinion should be accompanied by supporting evidence for one's reasons in the form of concrete examples, utilizing the relationship between *concrete and abstract*. This concept was explained using a triangular logic diagram. The former is a logical concept that can be used to explain things to others in a simple manner, while the latter is a concept that is necessary for communicating one's opinion with others. The goal is that students aspiring to become engineers will learn these concepts of logic.

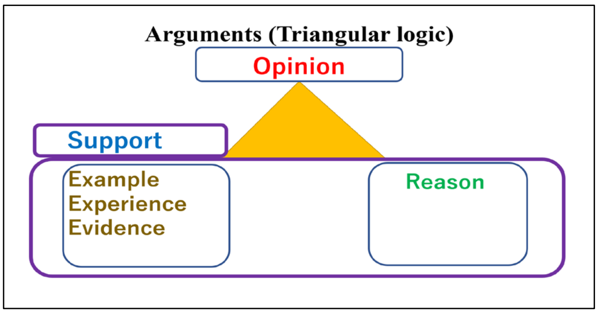

Figure 3: Triangular logic diagram

2-3-2 Practice Example 4: Logical Debate

Section D discusses logical debate as a form of verbal expression. At the start of this section, students expand on *assertion and evidence* as well as practice stating their arguments in English using the OREO method. A sentence is composed of: O (opinion), R (reason), E (explanation, evidence, concrete examples, anecdotes), and O (re-express the opinion). To write logical sentences, it is necessary to state an assertion, mention reasons for the assertion, and provide concrete examples and explanations to support those reasons. Hence, the OREO sentence structure was considered appropriate for this. In addition, higher-level concepts (reasons for the assertion) and lower-level concepts (concrete examples and explanations supporting the reason) were taught so that they could be organized and those unrelated to the assertion could be examined. Besides teaching the OREO structure, connecting words, such as conjunctions and ordinal numbers, were taught to make sentences cohesive. Students practiced expressing their opinions in English using supplementary materials during the first hour of the class.

Next, the students engaged in debates. Since most of the students were beginners, we decided to conduct small -scale debates, which were simpler and lasted for only15 minutes per round, allowed students to experience being debaters for both the affirmative and the negative, as well as the referee by conducting rounds in groups of three. After explaining the differences between debates and discussions, the students gained a better understanding of the format of the rounds, which were argument, followed by counterargument, and then final defence. The students then prepared a draft of their arguments and counterarguments, using the OREO method. The purpose was not only to deepen their understanding of the OREO method, but also to help them realize its effectiveness as a method of logical expression by applying it, thus improving the accuracy of their debates.

Figure 4: Debate class 2022.1

3. Results

A quantitative survey of 200 students was conducted to determine their level of enthusiasm and interest in language activities. Additionally, a qualitative survey was conducted to determine their level of awareness and enforcement of language differences.

3-1. Quantitative Survey

3-1-1 CLI Student Feedback Survey

Q: Were you enthusiastic and proactive in this class?
The responses were rated on a five-point scale. A total of 73% of the participants answered that they were. (class of 2020, 204 participants)

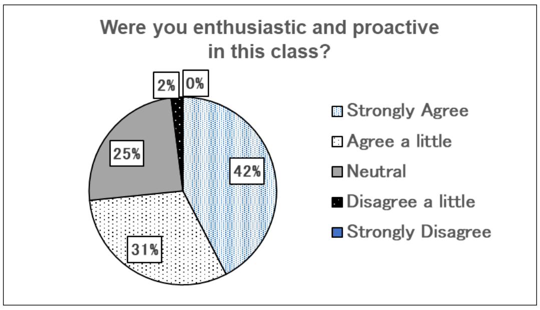

Figure 5: CLI Questionnaire (02. 2021, 204 responses)

3-1-2 CLI Student Feedback Survey

Q: Did any of the following change as a result of taking CLI in 2021? The responses were rated on a four-point scale. The following questions are related to the results of each section.

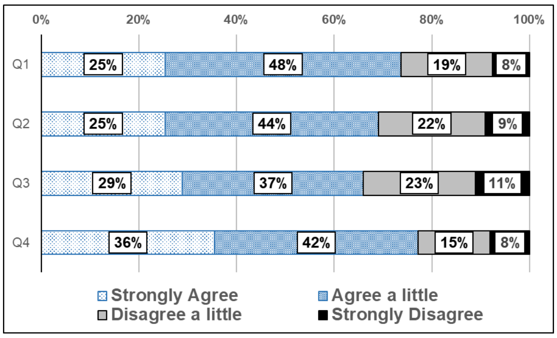

Figure 6: 2021 CLI survey (Conducted via Microsoft Forms, 197 responses in June 2022)

Q1. Did you become aware that there are differences in parts of speech and word order between Japanese and English as a result of taking this class? This result is related to the contents of Section A.
A total of 73% of the participants responded that they did.

Q2. Have you become more aware of conjunctions and context while reading? This result is related to the contents of Sections B and D. A total of 69% of the participants responded that they did.

Q3. Have you become more aware of the differences and similarities between Japanese culture and other cultures? This result is related to the contents of Section C. A total of 66% of the participants responded that they did.

Q4. Do you understand (have a deeper understanding) that the *assertion and evidence* concept of logic is an effective way to express yourself in both Japanese and English? This result is related to the contents of Sections B and D. A total of 78% of the participants responded that they did.

3-1-3 CLI Student Feedback Survey

Q. Were you actively involved in the debating rounds and the preparations? The responses were rated on a five-point scale. A total of 89% of the participants responded that they were passionately involved.

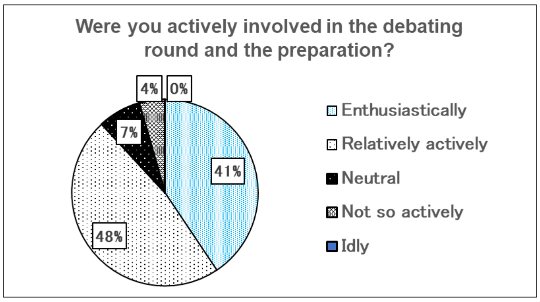

Figure 7: 2021 Debate Post-Class Questionnaire (01. 2022, 202 responses)

3-2 Qualitative Survey

3-2-1 Student Reflective Comments

Based on students' comments, we qualitatively assessed their increased awareness of meta-language and logical expression. The following comments were made by students in Section C (July 2020):
"By comparing the cultural differences between Japan and other countries, I was once again made aware that Japanese culture has its own unique characteristics."
"When I paid attention to conjunctions while reading, I was able to understand the meaning and general flow of the English sentences better than I had before." (Also related to Section B)
"Based on everything I've learnt so far, I feel like Japanese and English are very different and yet also similar" (Also related to Sections B and D)

The following comments were made by students in Section D (November 2021):
"I want to be more aware of OREO when asserting my opinions from now on, since writing with it in mind makes one's arguments stronger."
"I found that asserting opinions in both English and Japanese follow similar structures." (Also related to Section B)

The following comments were made by students in the Debate section:
"I felt that evidence was important. It was regrettable that I couldn't give much structure to my rebuttals. Next time, I would like to come back with much more solid evidence." (November 2021)
"During rebuttals, it was very difficult to quickly create a logical structure from the other side's argument, visualize it, and use it to convince the other side; however, I was able to develop the habit of instantly forming my own opinions and was able to grow as a person." (May 2019)

3-2-2 Teacher Reflective Comments

CLI allows teachers to learn from one another across subject areas. The effectiveness of this subject can be seen from the teachers' comments:

"*In the English Expression II class, to deepen the discussion of Japanese word order in Section A, the differences between English and Japanese word order*

are dealt with in more detail. This is a very effective cross-language teaching method because it allows the class to incorporate comparisons with other languages, rather than the conventional English perspective." (English language teacher's comment)

"The results of CLI were not limited to this class alone but had no small ripple effect. The concept of "claim and evidence" logic, which is taught in Sections B and D, and "OREO" as a development of this concept, are sometimes brought to the attention of students in first- and second-year Japanese classes. In addition, when teaching third-year students how to prepare documents related to higher education and employment, and how to prepare for interviews, we had them use this concept of logic in writing their preparatory drafts. In this way, a situation is being created in which CLI content is first used as the basis for expressive activities, which are then developed and taught in Japanese language classes. In the process, we have often recognized the usefulness of the CLI content, which has renewed our desire to improve the classes." (Japanese language teacher's comment)

4. Discussion

The quantitative data from 3-1-1 to 3-1-3 indicate that students were able to engage in language activities with enthusiasm and positive attitude, while being aware of language differences. This indicates that the students were able to notice the differences in language and culture through comparisons in the lessons during Sections A and C.

The qualitative data were examined and categorized to discover commonalities or issues in different contexts. From the results of 3-1-2 and 3-2-2, students were able to compare logical thinking in terms of *concrete and abstract* as well as *assertion and evidence* in their native language and in English. Through the lessons during Sections B and D, they were able to improve their motivation for logical expression and to reflect on what they want to communicate to others in a simple manner.

By noticing differences through comparison, students become more aware of their language and more effective in using it. As they became more aware of their own logical language use, they become more interested in the cultural differences behind it and were more willing to engage with others from different backgrounds. Therefore, CLI is an innovative approach in cross-language education.

5. Conclusions

We were able to implement new trials and obtain certain results in CLI. The results are directly related to the development of abilities required of future-oriented engineers. Through the awareness of differences gained in class, students will become more proactive in their interactions with others in a global society. In addition, the ability to express oneself logically, which is expected of individuals in Society 5.0, cultivated through liberal arts education, and CLI is precisely the subject that corresponds to this requirement.

The next objective is to incorporate more expression related activities into the class, such as presentations and debates in English. In CLII, the spiral-up version of CLI, the theme will be to "create thoughts from words and words from thoughts," where we would aim to further hone the students' communication skills, so that they will be able to fully utilize language as a tool for expression and thinking.

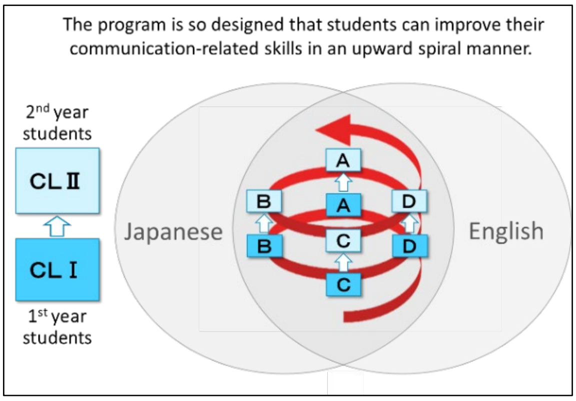

Figure 8: From CLI to CLII

Appendix: Outstanding achievements in the field of expression from those who took CLI and CL II

1. First place in the 2020 Biblio Battle, Tochigi Prefecture, second place in 2021.
2. National High School Students' Reading Experience Contest (sponsored by Hitotsubashi Literary Education Promotion Association): Tochigi Prefecture first prize in 2020, second prize in national competition in 2021, and many other prizes

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CONSTRUCTION AND PRACTICE OF PATTERN RECOGNITION IN THE MEDICAL ENGINEERING COURSE

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Abstract

The intelligent medical engineering major is still in its infancy, and the social demand is huge. Not only is there a shortage of high-level talents, but also the cultivation of applied undergraduate talents is imminent. "Pattern Recognition" is the core course of intelligent medical engineering, which plays an important supporting role in the achievement of the cultivation goal of medical-engineering compound talents. Aiming at the two "pain points: the depth and the breadth of the course increase the difficulty of learning for students " in course teaching, the team established the teaching reform concept of " student-centered, blended teaching method, destruction and reconstruction of course content system", and condensed the teaching innovation idea of " reverse course goals with expected learning effects, personalized learning process and incremental assessment standards". Through in-depth analysis of the basic learning situation of our school, deconstructing and reconstruction of course teaching content, relying on the information teaching platform of our school, combined with diversified teaching methods and diversified assessment methods, the course is built into a fusion of theory and practice, an integration of knowledge and moral education, an integration of teaching and innovation. We have realized online and offline hybrid courses, achieved the reform effect of good expected learning effect of students and improved the teaching level and scientific research level of teachers. The promotion value of the course is reflected in: (1) We have already accumulated rich course resources. So the course has a wide coverage and can benefit a large area and it is feasible to promote to other institutions of the same type; (2) The hybrid course construction mode and innovative teaching design have the promotion value of point-to-line and line-to-surface promotion in related majors inside and outside the school.

Keywords: *Vocational Education, Student-centered, Hybrid Course, Personalized Learning Process, Incremental Assessment*

Introduction

"Pattern Recognition" is a course that studies the theory and method of information classification and recognition, and its comprehensiveness and intersection are very strong. In terms of connotation, pattern recognition involves data processing and information analysis methods; in terms of application, it belongs to the category of artificial intelligence and machine learning. The course requires a strong mathematical foundation, including advanced mathematics, probability theory and mathematical statistics, linear algebra, etc.

"Pattern Recognition" is the core course of intelligent medical engineering. It is offered in the junior year, with a total of 64 hours, including 48 hours of theoretical content and 16 hours of classroom experiments. This course teaches the basic principles and methods of pattern recognition for undergraduates, and solves three basic problems of pattern recognition: feature extraction and selection, learning and training, and classification and recognition. It can be used in medical image processing, electronic medical record analysis, auxiliary medical diagnosis and other fields. It aims to cultivate students' ability to analyse and process medical information, and then improve students' practical ability in intelligent medical engineering.

Description of the problem

Since the establishment of the pattern recognition course in our school, a total of 8 years of teaching have been implemented. The lecturer began to teach the pattern recognition course in 2016. So far, a total of 7 rounds of iteration and update of the teaching content have been carried out. Through the analysis and summary of the experience, the two problems that need to be solved urgently in the course are sorted out:

1) The contradiction between the theoretical depth of the course and the academic situation of our school

Our school aims to cultivate application-oriented talents. The grades of students when they enter the school are relatively ordinary, and some students are more serious. From the perspective of knowledge mastery, the mathematical foundation and the theoretical foundation of artificial intelligence are relatively poor; from the

perspective of learning ability, After the first two years of study, students have basic programming thinking and practice level, but it is difficult to understand more abstract algorithms, so they lack the comprehensive analysis ability of in-depth thinking; from the perspective of student quality, students already know that the use of algorithms can solve practical problems, but it is easy to feel intimidated by more complex problems.

The pattern recognition course is highly theoretical, and there are many algorithmic derivation and proof processes. This requires students to have a high degree of mastery and application level of pre-course courses such as linear algebra and probability theory. However, if the study of algorithm theory is completely abandoned, students will easily Falling into the situation of "knowing it but not knowing why" leads to a disconnect between knowledge mastery and ability improvement, and it is even more impossible to train students' scientific thinking, critical thinking, innovative thinking and other qualities. Therefore, how to overcome the contradiction between the difficulty of the course and the lack of students' quality and ability is very important.

2) Confusion between mature algorithms and fast iterative new algorithms

Pattern recognition originated in the 1950s. After a vigorous period of vigorous development, due to hardware limitations, it entered a cooling-off period in the 1970s. With the rapid increase in GPU computing power, research has entered a revival period, science 2010, new algorithms, new technologies, and new platforms emerged one after another. Therefore, the knowledge structure of pattern recognition courses includes both relatively mature algorithms and emerging algorithms. How to select relevant knowledge reasonably and effectively for students under the premise of new technology and new application is particularly important.

Methods and Pedagogy

As an institution for cultivating applied talents, the design of courses must follow the specific conditions of our students, and formulate course content that conforms to their knowledge level and cognitive laws. In response to the above problems, combined with the cultivation goals of this major, a series of innovative designs have been carried out in the teaching concept, teaching content, teaching methods and means, and teaching evaluation of the course. The main concepts and ideas are as follows:

1) Online and offline blended teaching

Since the outbreak of COVID-19, new situations such as online learning and working have greatly affected traditional teaching methods. Faced with the new situation, the course team makes full use of our school's information-based teaching platform, making online and offline hybrid teaching an important means to solve students' all-round and full-process learning. Comprehensive use of the above-mentioned information platform enriches students' learning channels; in addition, students are trained to use programming languages to verify relevant theoretical algorithms in combination with practical links, and students' comprehensive application ability, autonomous learning ability, and teamwork ability are tested through course projects. It strives to combine the advantages of traditional learning methods and online learning, organically integrate the two learning modes of face-to-face teaching and online learning, and fully reflect the initiative, enthusiasm and creativity of students as the cognitive subjects of the learning process. Teachers guide, inspire, monitor teaching process, so as to obtain the best learning effect.

2) Deconstruction and reconstruction of course content system

Based on the decomposition of the professional cultivation goals, the teaching objectives of this course are determined, and then the course content system is reconstructed: the major aims to cultivate applied talents with the combination of medicine and engineering, so the complicated and difficult mathematical proof process of the course is weakened. Aiming at the three basic problems of pattern recognition, the selection of a typical algorithm, and the origin, process, advantages and disadvantages of the algorithm are introduced, while ensuring the integrity of the knowledge structure, focus on the practical application of the algorithm, and gradually cultivate students' practical ability and self-learning ability through the class experiments and course projects.

Timely update and optimize teaching content based on industry development: At present, most of the pattern recognition courses in traditional colleges and universities use C/C++ programming, which is more focused on algorithmic programming, which is not conducive to students' understanding and innovation of algorithm application. The syntax of Python is simple, development efficiency is high and open source resources are rich. MATLAB simulation function is powerful, and data visualization can be realized. This course selects Python and MATLAB as the experimental platforms based on the development of pattern recognition field to conduct experiments and project development, and timely upgrades according to their update conditions. So the course enables students to understand the development and industrial application of pattern recognition algorithms, the application of new products and new tools in the industry. And the course focuses on the training of students' practical ability, and lays a good foundation for students' follow-up development and employment.

3) Diversified course resources help students to personalize their learning

Relying on the advantages of our school's hybrid teaching reform, the "online and offline teaching" model was introduced into the course. The course team designed and produced 10 micro-lecture videos and launched the information platform, covering all major and difficult points. The practical part of the course includes 6 experiments and 1 course project, which realizes the combination of theory and practice. For different links of

blended teaching, various types of teaching resources are carefully designed, as shown in Figure 1. These resources are organically integrated with the course, and students can view the course standards and teaching calendar online to learn about the course objectives, course priorities, and assessment information. Before class, students check the pre-class task list, understand the learning requirements, learning tasks, and learning resources, check the corresponding resources according to the task list, and complete online tasks; Use a variety of teaching methods to strengthen knowledge and expand appropriately in the form of flipped classroom discussions. After class, students focus on difficult content and complete online practice questions. Through a variety of forms and means to mobilize the enthusiasm of students in an all-round way, make full use of resources, so as to ensure high-quality teaching effects.

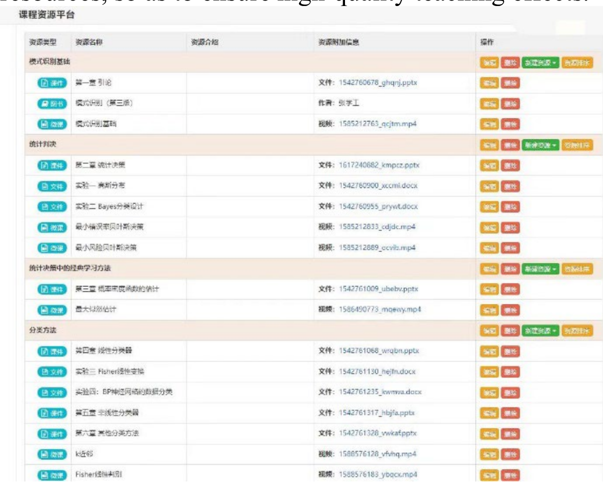

Figure 1 Some examples of the course resource platform

Two of the assignments assess students' understanding of key knowledge, and the content of the assignments is different for each student to prevent plagiarism. For example, when learning the Bayesian classifier, teacher requires students to make their own questions: analyse the loss of taking classes or not, and make a decision on whether to take classes or not. The homework example is shown in Figure 2. Therefore, students understand the abstract concept of "loss" more concretely, and realize the subjectivity of "loss", which provides a vivid reference example for the design of future algorithms. Six experiments are conducted to assess students' ability to use theoretical knowledge to solve pattern recognition problems, and to ask individualized questions about algorithm codes to understand students' actual mastery level, which fully mobilized students' enthusiasm for learning.

The course project is self-proposition. Students are divided into groups of 3-4 people, and select the algorithm and programming language to be used for the topic of personal interest, and complete the design of the pattern recognition application system. Under the premise of ensuring the fairness and effectiveness of the assessment, students are free and given full play to their initiative and innovative thinking. For example, students independently complete the design of the pattern recognition experimental platform, including a variety of feature extraction methods, the selection of classifiers, and the visual presentation of the solution process of the three basic problems of pattern recognition, as shown in Figure 3.

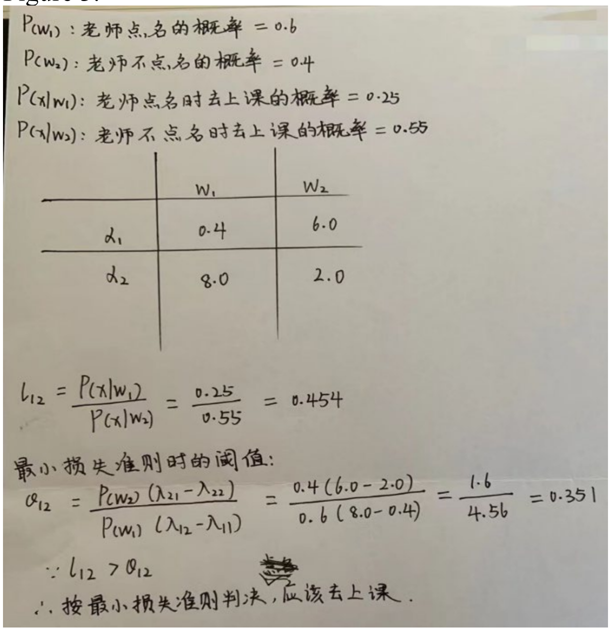

Figure 2 Example of self-proposition homework

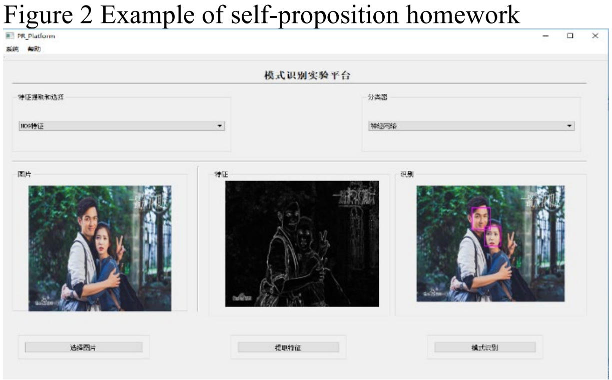

Figure 3 Example of course project - pattern recognition experimental platform

4) Reversely reconstruct the curriculum system with the expected learning effect

Under the guidance of student-centred thinking, combined with TOPCARES ability indicators, through the expected learning effect, the quality, ability and knowledge goals of the course are reversed. Through the analysis of the service orientation and professional orientation of the intelligent medical engineering major, the graduation requirements are determined, and then the expected learning effect is planned, and the teaching objectives of the course are reversely derived. Through each link of teaching activities, the expected learning effect is achieved, and such a closed-loop teaching design realizes the reconstruction of the course content system.

The degree of achievement of the expected learning effect is verified by the incremental assessment standard. In the assessment and evaluation, it is not only measured by the score, but more concerned about the learning output of the students: what the students have gained after studying this course. Combined with the

TOPCARES ability indicator, the design of course value is shown in Figure 4, and we try to promote more students to achieve their goals, some students to achieve higher goals, and all students to achieve larger increments.

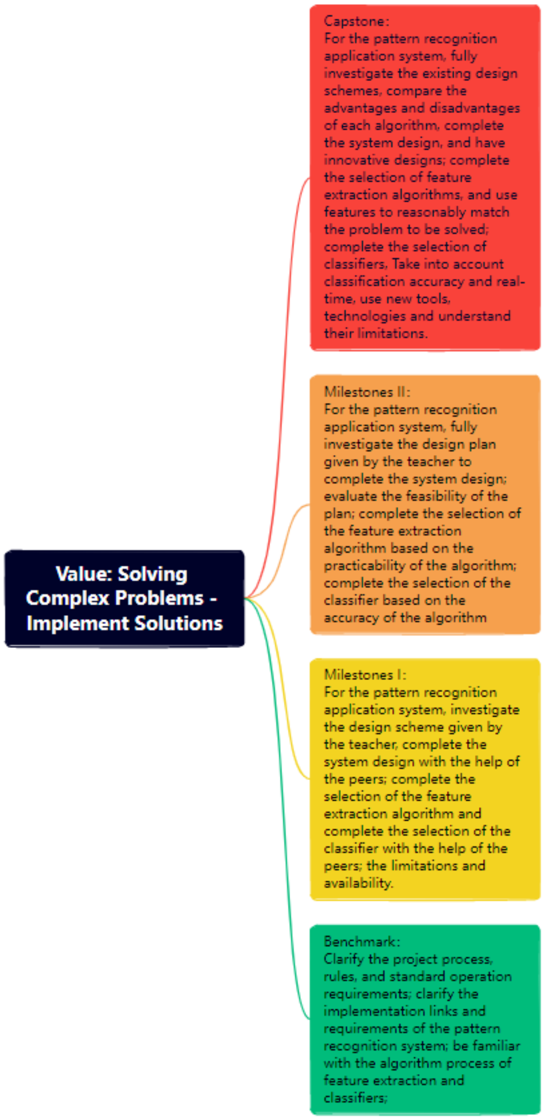

Figure 4 Example of course value design

Results and Discussion

Through the online and offline hybrid teaching platform and the reconstruction of the course content, the learning difficulty of the students is reduced, and the learning interest of the students is greatly improved. The students are more willing to use the information platform for learning. The specific learning data is shown in Figure 5.

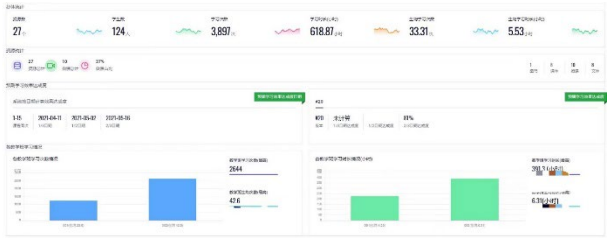

Figure 5 The usage of the course online platform

The improvement of learning interest promotes the achievement of the expected learning effect, and the students' knowledge, ability, quality and other goals have been fully exercised. For example, in the course project, the teacher integrates the research project, and the students participate in the pre-processing of the gait data, feature extraction, classification and identification, and the whole process of forming a rehabilitation treatment plan, and have a deeper understanding of the mission of technology to change life and technology to serve the society, as shown in Figure 6.

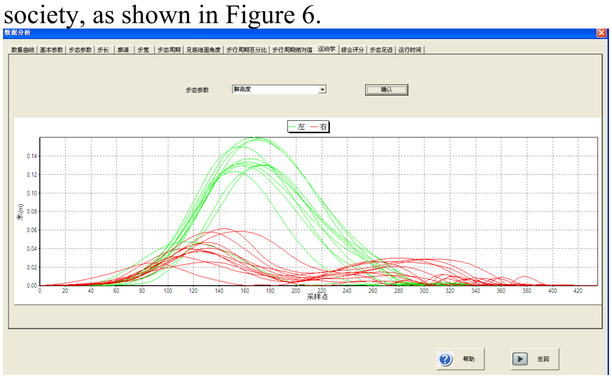

Figure 6 Teacher research project - gait analysis

Conclusions

Pattern recognition is the core course of intelligent medical engineering major. The knowledge content involved is very complex and the theoretical depth is relatively large. However, our school has recruited intelligent medical engineering major since 2019, which is still a newly established major. Therefore, for some knowledge content, it will be more difficult to understand, so the practice of blended teaching method in the teaching process helps students to accept the course . In the future, we will continue to explore the practice of blended teaching, enrich the corresponding teaching resources, increase the practical content in the medical field, and provide better support for the learning of courses related to intelligent medical engineering.

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APPICATION OF VR TECHNOLOGY TO THE TRAINING OF METAL CASTING FOR JEWELLERY INDUSTRY

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Abstract

Metal casting is a common traditional metalwork process widely used in the jewellery industry. The principle of the process is not too complicated but the operation itself requires a learning curve and it also poses several hazards to the artisans. Unlike many large businesses that have used VR, such as those in the engineering and construction industry, VR-based training is seldom applied in the casting manufacturing process in the jewellery industry. In this paper, a group of project students, with the help of domain specialists, attempt to develop a VR-based training tool for the metal casting practitioners. The content includes the introduction of the benefits in using VR-based training, understanding of the metal casting process, surveying the needs of the practitioner, and investigating the use of VR in the metal casting process. To evaluate the effectiveness of VR-based training tool, feedback is collected from local jewellery companies. The development process of the VR system and the use of it during pandemic will also be evaluated.

Keywords: *jewellery industry, metal casting, lost-wax casting, virtual reality, safety*

Introduction

Hong Kong is one of the world's largest jewellery exporters, making important contributions to Hong Kong's economy. In 2020, the industry comprised 210 manufacturing establishments and 3,300 import and export establishments, employing a total of 14,140 people (Man, 2021).

Traditionally, during the manufacturing process of jewellery, metal casting ("lost-wax casting") is a standard procedure but it is a process with potential risks. Without sufficient training, it is especially dangerous to junior artisans because of its potential burn and eye hazards. Nowadays, VR technology has been widely applied to different high-risk scenarios to provide a safe and regular training platform for workers. VR based training platforms can help instructors to provide hands-on, practical training of metal casting in a safe virtual environment, increasing workplace productivity and safety. Hence, a study to understand the benefits and limitations of deploying a VR based training platform in the jewellery industry is formulated.

This paper will discuss the following sequence: First, the paper reviews the process of metal casting and the challenges and risks in conducting training. Second, it focuses on discussing different training modes. Next, it describes the development of the VR training application. Then, it discusses the benefits and limitations of applying a VR training platform in the jewellery industry over traditional methods.

Challenges and Risks in Teaching Metal Casting

The jewellery industry of Hong Kong remains basically a handicraft industry whereby the production of jewellery still mainly utilizes lost-wax casting. It is an ancient method by which a duplicate metal is casted from an original wax pattern. To further describe the challenges and risks in teaching lost-wax casting, an overview of the jewellery making process will be illustrated below.

Lost-wax Casting

Jewellery making process can be divided into five steps: *concept design, wax crafting, wax tree preparation, lost-wax casting, refining and polishing*. As per usual practice, after a design is selected, it will be crafted into a wax model. Then, the wax model will be duplicated and connected to one another on a wax sprue to form a tree-like configuration. The wax tree will be then suspended inside a metal flask and filled with plaster slurry. After the plaster is hardened, it will be placed in an electric kiln, where the wax will be incinerated at a temperature at around 800°C for 10 or more hours. The wax will then be burned out, leaving a hollow impression of the wax tree and will be ready for pouring in the molten precious metal for batch production. When the metal is cooled and

solidified, it will be quenched in water for further cooling and the heated plaster will be broken away due to the temperature differences. The remaining plaster will be further chipped away, leaving behind a tree containing the metal models as branches. The models are then cut free from the sprue and forwarded to jewelers who will execute jewellery polishing, jewellery fabrication, or stone setting to transform the casting into fine jewellery (Underhill, 2021).

Traditional Training Platform

As for the teaching of jewellery making, although computer-aided design has been widely adopted, training institutes and production premises still mainly utilize traditional methods such as demonstrations, lectures, discussions, hands-on workshops and technical visits. Obviously, under the impact of the COVID-19 pandemic, most of these activities have been changed to home-based training, utilizing pre-recorded lectures and demonstrations as a new teaching strategy.

As can be seen from the table below, with the adoption of new technologies, many steps in jewellery making such as 3D modeling and printing can be trained without being confined to a workshop setting. For instances, since concept design and crafting the wax model can be done with a computer anywhere, the level of difficulty of using home-based training is low and the score is 1 to 2. Nevertheless, for metal casting, due to high facility requirements and as the handling of high temperature molten metal is highly hazardous, it can only be operated in a workshop setting with proper guidance.

Table 1. Comparison between traditional and technology-enhanced modes

	Level of difficulty using home-based training (1 = low and 5 =high)	**Traditional tools and material**	**Technology-enhanced tools and material**
Concept Design	1	Papers, Pens	2D CAD PC
Wax crafting	2	Wax Sculpting tools	3D CAD PC 3D printer Wax/resin
Wax tree preparation	3	Wax, Rubber base, Soldering iron	3D CAD 3D printer Wax/resin
Lost wax casting	5	Electric Kiln , Vacuum chamber, Metal flask, Metal tongs, Water tank etc.	N/A
Refining and polishing	3	Electric Grinder, Sandpapers	N/A

With the initial findings that lost-wax casting is apparently the bottleneck for training jewellery artisans, a survey has been conducted to understand the training attitude associated with the traditional training mode and the technology-enhanced mode experienced by the trainees in the jewellery industry and training institutes in Hong Kong. Data from 53 respondents from the online survey were collected. The survey results show that trainees are more familiar with traditional mode and believe real practice is necessary for skill improvement. However, over 85% of respondents agree that the delivery of the training is not efficient because of the long setup time and idle time (Fig. 1).

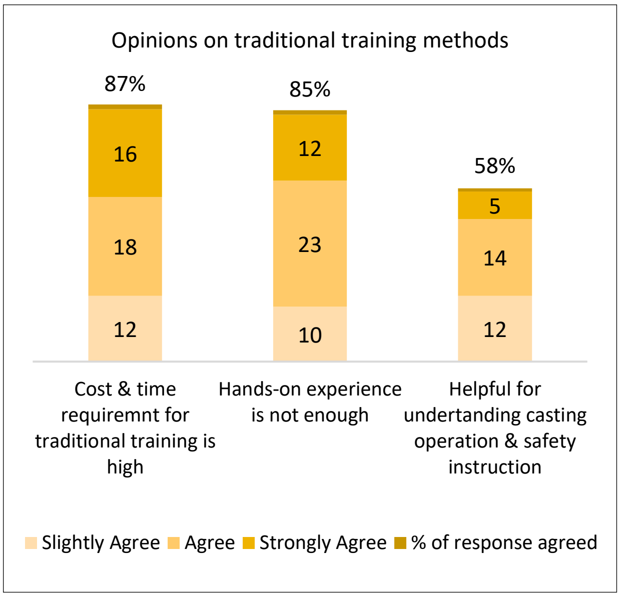

Fig.1. Trainees' attitude to traditional training

Technology-enhanced Training Platform

Despite the fact that traditional mode cannot be replaced in skill-based training, technology-enhanced mode is highly acceptable by users. Based on the survey, most trainers and trainees have heard about AR, VR or MR trainings but have not experienced them before so they are keen to try. They believe that it will enable off-site training which allows for more time and place flexibility.

Over 75% respondents agree that it will help improve their skills since more practices can be done even if the workshops are closed. As the training can be conducted repeatedly without much extra cost, the trainee will be more familiar with the process and become more confident to do the work in the real-life setting.

Many of them also agree that visual and audio cues in immersive trainings can effectively alert them about potential risks and emergency handling in a more memorable way (Fig. 2).

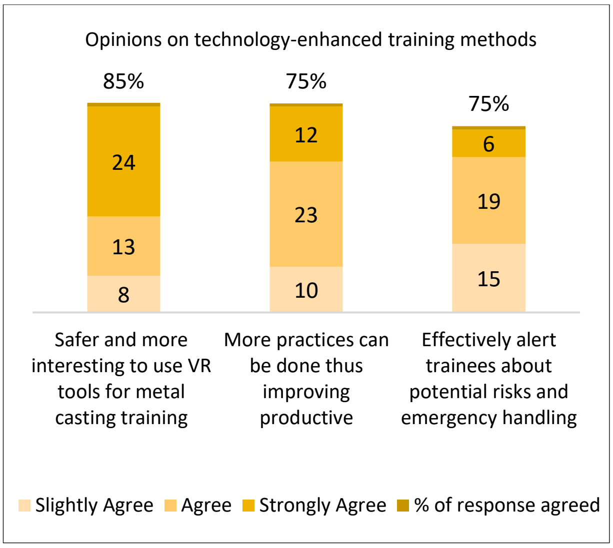

Fig.2. Trainees' attitude to technology-enhanced training

Development of the VR training package

The development cycle of VR training varies from 8 weeks to 6 months or more, depending on its complexity. Generally, it can be divided into 3 stages: storyboarding stage, asset building stage, and development and programming stage. During the storyboarding stage, the lost-wax casting procedure has to be deconstructed and understood, with the help of field experts. The training objectives and critical tasks, especially for those where safety hazards are involved, have to be defined carefully. After the storyboarding stage, digital assets such as 3D models of the workshop environment, equipment, tools and objects have to be built using 3D CAD modeling tools such as 3ds Max. The final stage involves loading the digital assets into the VR authoring software such as Unity 3D and using scripting to assign the necessary interactions and responses for the users as planned. This stage will require many back-and-forth testing until the application can be deployed.

Experience with the VR Training Platform

With the development of the VR training package completed, a user acceptance test is conducted. Since most people have heard about virtual reality, trainers and trainees are enthusiastic to try and provide feedback for the VR training platform. According to the user feedback collected, many users agree that the immersive experience of the VR training is more realistic than they expected.

Over 51% of users agree that the simulated environment looks very close to the real-life work environment and many more feel that they are more confident to perform the tasks after taking the VR training.

While the general acceptance of adopting a VR platform in training is high, there are some downsides of the training experienced by the users. Based on their feedback, over 70% of respondents express that the responds of the motion controllers are slow or not in sync sometimes (Fig. 3).

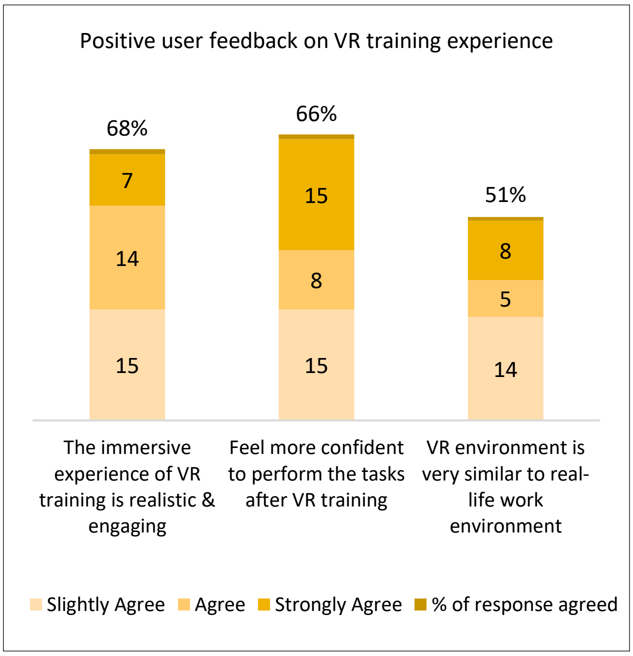

Fig.3. Positive user feedback on VR training experience

It should be noted that most VR platforms are sensitive to interference and require a space of at least 2 by 2 meters, free of tripping hazards such as chairs, tables, or anything you can bump into during training.

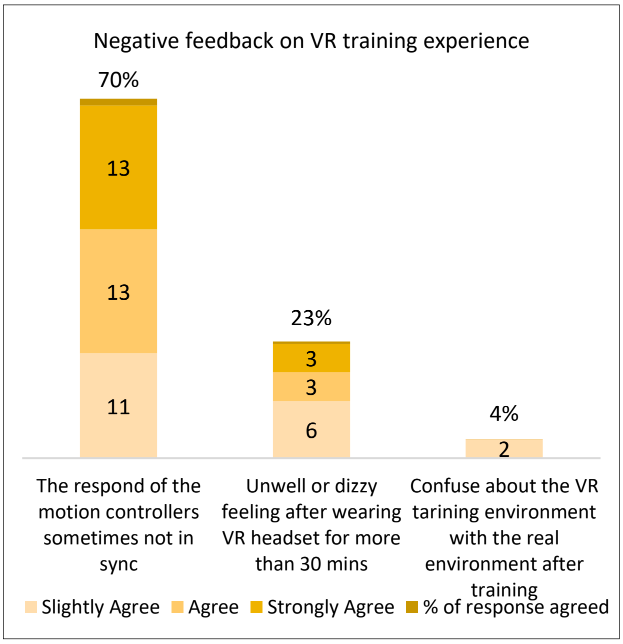

Fig.4. Negative user feedback on VR training experience

Furthermore, results from the survey also show that it is not uncommon for people to feel unwell or dizzy after wearing a VR headset for more than 30 minutes (Fig. 4). Research has shown VR tools should have at least 90 frames per second (fps) to reduce the chance of having motion sickness (Hecht, 2016). The refresh rate of the display has to be faster than the image processing time of one's brain to prevent dizziness. To avoid the chance of having motion sickness, VR tools with fps less than 90 should be prevented. Also, based on the survey result, the duration of the training session should be within 30 minutes since most people may feel tired or comfortable in such duration (Fig. 4).

Discussion on using VR Training Platform on Metal Casting

According to the survey results, over 83% of respondents believe that using technology-enhanced training in the industry will help improve the industry's image and can attract the younger generation to join the industry. Over 60% of respondents find the VR platform easy to use and can reinforce their memory about the operations and safety measures. Unlike traditional training, VR training allows for trial and error and can be done repeatedly many times without extra cost. Trainees can explore the metal casting process safely themselves for better understanding (even during the COVID impact) thus the training time can be shortened (Fig. 5).

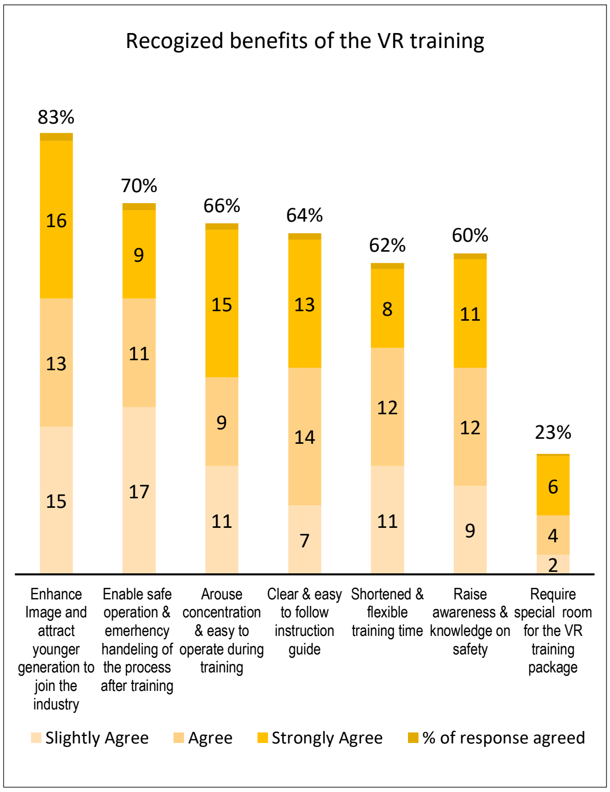

Fig.5. Recognized benefits of the VR training experience

On the other hand, over 60% of the respondents think that high development costs and long development cycle will be obstacles for the adoption of VR training in the industry (Fig. 6).

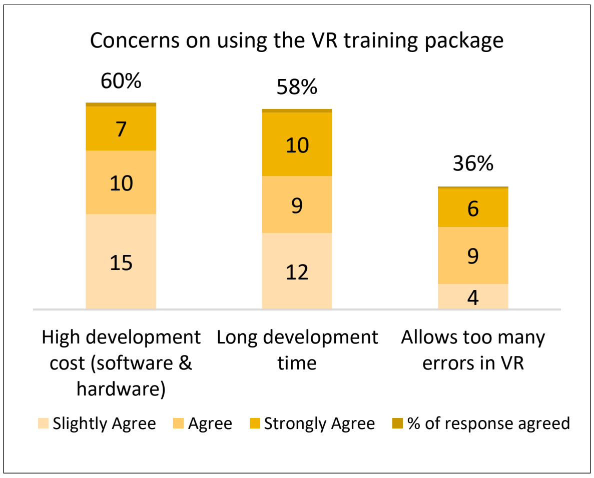

Fig.6. Concerns on using VR training package

There are also concerns that the cost of VR software and hardware are high and may require a special room to setup the VR system (Fig. 6). While some of these concerns are valid such as the high resource requirements for development is still high and may require support from government funding, the costs of hardware and software are falling steadily every year.

VR headset and controllers which used to cost more than $8,000 can now be substituted by alternative solutions at a one-third of the price. VR manufacturers are cutting down on the price and there are more standalone VR headsets which do not require attaching to computer nor fixed sensors, allowing training to be conducted in any free space.

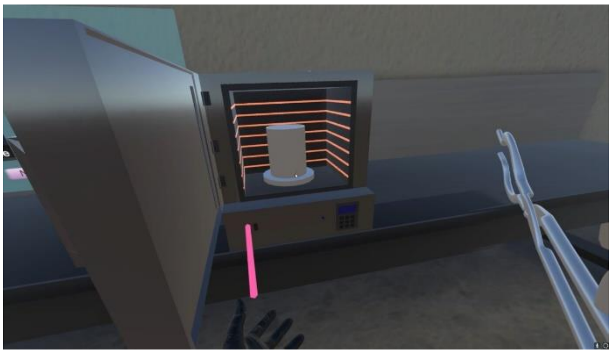

Fig.7. Screen Capture of the VR training package

Conclusions

This paper reviewed the jewellery making process in the industry and the challenges faced in training up the younger generation. The research identified that the

traditional way of metal casting training is costly and time consuming. Because of the occupational hazards associated with the process, metal casting can only be trained in workshops thus has a lot of constraints. Considering technology-enhanced learning, a VR based training platform is applied to the metal casting process, where only traditional ways of training have been used. In the findings, the VR training platforms can help trainees become confident and skillful so as to minimize the chance of accidents happening in real-life situations. Although traditional training mode cannot be replaced, VR based training platform enables interactive learning and allows great flexibility for different needs of the trainees. During the COVID impact, trainees can still have some hands-on experience even without the instructors or when the training facilities are closed. With the performance improvement and price drop in VR hardware and software, the growth of using this technology in education and training is promising. In the future, the research team will enhance the realism and the instructional design of the VR platform and share its experiences in the future.

Acknowledgements

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A HARRY POTTER THEMED DIGITAL ESCAPE ROOM FOR ADDRESSING MISCONCEPTIONS IN CHEMISTRY

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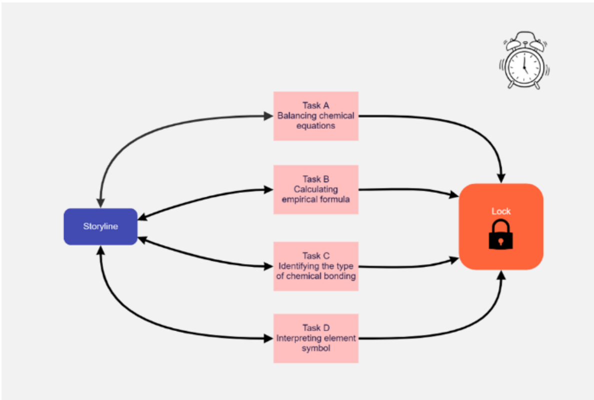
Abstract

Chemistry is often seen as an abstract and content-heavy subject. Many students struggle with Chemistry because they attempt to memorize the content without understanding the concepts. As a result, students often have misconceptions. COVID-19 has driven teaching and learning online and an escape room teaching method, which is a way to enhance student engagement, has gained popularity among educators in higher education. This study examines the effectiveness of teaching through a digital escape room as compared to a typical online lesson with a collaborative learning method, in addressing misconceptions in Stoichiometry. A Harry Potter themed digital escape room is created to spark the students' interest in Chemistry and address misconceptions. 38 students from the Nanyang Polytechnic Foundation Program participated in this study. The students completed a pre-test, a post-test, and a survey, in addition to participating in the digital escape room and a typical online lesson. Four topics were covered in this study: balancing chemical equations, calculating empirical formulas, identifying the type of chemical bonding, and interpreting element symbols. Out of these four topics, it was discovered that students tended to have difficulty calculating empirical formulas. It was found that, on average, students showed a 10% improvement in test scores after being taught through the digital escape room. This result is similar to results obtained from a typical online lesson with a collaborative learning method (9% improvement). This implies that a digital escape room is equally as effective as a typical online lesson with a collaborative learning method, in addressing misconceptions. Teaching through a digital escape room has shown potential additional benefits of enhancing soft skills, promoting teamwork, the ability to work under time pressure, communication skills, innovation competency, and increasing student motivation. The researcher recommends the use of a digital escape room to complement typical lessons for these additional benefits.

Keywords: *Higher Education, Introductory Chemistry, Collaborative / Cooperative Learning, Humor /Puzzles/ Games, Internet / Web-Based Learning, Misconceptions*

Graphical Abstract



Introduction

Chemistry is often seen as an abstract and content-heavy subject (Ben-Zvi, Eylon, & Silberstein, 1987; Cardellini, 2012; Gabel, 1999; Johnstone, 1991; Mahdi, 2014; Nakhleh, 1992). Many students struggle with Chemistry because they attempt to memorize the content without understanding the concepts (Hussein & Reid, 2009). As a result, students often have misconceptions (Nakhleh, 1992; Üce & Ceyhan, 2019). Correcting students' misconceptions is challenging for educators because students may be reluctant to alter their thinking or are unaware that their concepts are incorrect.

The target group in this study was students from the Polytechnic Foundation Program (PFP) under the Applied & Health Sciences cluster. A total of 71 PFP students, aged 16-17, from three classes, were invited to participate in the study. 38 students participated, and they came from a variety of social, economic, and cultural backgrounds. Four topics: balancing chemical equations, calculating empirical formulas, identifying the type of chemical bonding, and interpreting element symbols were covered in this study. Out of these four topics, it was discovered that students commonly have misconceptions about calculating empirical formulas.

In this study, it was discovered that students had the misconception that mole ratios with decimal places should always be rounded off to the nearest whole number when calculating empirical formulas. For example, given the mole ratio of element A: element B is 1:2.5, students tended to round off the mole ratio, stating the empirical formula to be AB_2 or AB_3. The correct way is to multiply the mole ratio by a multiple of 2 to get the empirical formula to be A_2B_5. This misconception occurred because students had prior knowledge of how to round off a decimal to a whole number, and since the empirical formula is the lowest whole number ratio of the elements, students simply rounded off the decimal places. This misconception occurred as students did not understand that elements A and B are related proportionally. Indeed, stoichiometry is a difficult topic to teach and learn, as pointed out in several studies (Dierks, 1981; Duncan, & Johnstone, 1973; Kolb, 1978; Novick & Menis, 1976; Sostarecz & Sostarecz, 2012). This study aims to evaluate the effectiveness of addressing misconceptions in stoichiometry through a digital escape room compared to a typical online lesson with a collaborative learning method.

An escape room was chosen because it offers several benefits. It provides an immersive learning environment, promotes active learning, develops teamwork, problem-solving, and communication skills, and increases students' motivation and engagement (Veldkamp, van de Grint, Knippels, & van Joolingen, 2020). A digital escape room was preferred to a physical escape room as the study was conducted during the COVID-19 pandemic.

Escape Room in Education Setting

An escape room is a submersion into a scenario built around a specific theme. In designing the escape room, choosing the theme is important. Harry Potter was chosen as the theme due to several reasons. Chemistry is just like magic, where objects can change color and can appear or disappear right before one's eyes. In addition, Harry Potter is well-known, and students will be able to identify with the school setting. Students can also find some similarities in the apparatus seen in the Potions classroom and the Chemistry laboratories in their schools.

In a typical escape room, a team of players is locked in a room, and they are given a fixed amount of time (usually an hour) to discover clues, solve puzzles, and escape. Since it is not practical to convert a classroom into an escape room for one lesson, an alternative format is proposed to reproduce the mechanisms and the experience at a reduced cost. The original plan was to create a mobile escape room for face-to-face lessons. A mobile escape room is a box or envelope which contains a set of puzzles. However, due to the COVID-19 pandemic and safe distancing measures, a digital escape room was created instead.

Digital escape rooms have gained popularity amongst educators in recent years (from 2017 onwards) (Makri, Vlachopoulos & Martina, 2021). They have been used mainly in higher education and in the following subject areas: STEM (science, technology, engineering, and mathematics), health sciences (e.g., Nursing), and natural sciences (e.g., Chemistry). There are several explanations why digital escape rooms are more commonly used in higher education than in secondary and primary education. Higher education institutions usually have better resources, and their educators have high levels of expertise in digital technologies and are more research-focused, whereas younger students make less use of digital technologies (Makri et al., 2021).

Digital escape rooms offer additional benefits compared to physical escape rooms. They are cost-effective, accessible, and easy to use. Their popularity could have been driven by COVID-19, whereby education has been disrupted and many educational institutions worldwide were forced to adopt remote learning and online lessons. Digital escape rooms offer an alternative to passive online learning.

Several educators have created physical and digital escape rooms for teaching Chemistry in polytechnics, high schools, and universities (Ang, Ng & Liew, 2020; de Souza & Kasseboehmer, 2021; Dietrich, 2018; Ferreiro-González, Amores-Arrocha, Espada-Bellido, Aliaño-Gonzalez, Vázquez-Espinosa, González-de-Peredo, Sancho-Galán, Álvarez-Saura, Barbero, & Cejudo-Bastante, 2019; Nguyen, 2018; Peleg, Yayon, Katchevich, Moria-Shipony & Blonder, 2019; Vergne, Simmons & Bowen, 2019; Vergne, Smith & Bowen, 2020). These shared experiences focused mainly on the development and effect of escape rooms on student motivation. There is no reported study on the effectiveness of escape rooms to address misconceptions in stoichiometry. This study compares students' performance in calculating empirical formulas before and after experiencing the digital escape room compared to a typical online lesson with a collaborative learning method.

Designing the Digital Escape Room

A digital escape room is an example of gamification. Gamification, defined by Deterding, Dixon, Khaled and Nacke (2011), is the use of game design elements in non-game contexts. The concept of gamification is different from that of an educational or serious game. While the latter describes the design of full-fledged games for non-entertainment purposes, "gamified" applications merely employ elements of games (Dicheva, Dichev, Agre & Angelova, 2015).

Design principles in creating digital escape rooms:

- Goals: Goals must be clear and specific.
- Theme: The theme must be appropriate and relatable to the students.
- Rules: Rules of the game must be clear.
- Player control: In an open structure, players can solve different puzzles at the same time and all puzzles need to be solved before the last one. In a sequential structure, the puzzles are presented one after another;

solving a puzzle unlocks the next (Makri et al., 2021). Allow multiple attempts and freedom to fail.

- Difficulty of the puzzles: Easy puzzles can become boring while difficult puzzles can cause frustration and a high drop-out rate. One way to mitigate the issue of difficult puzzles is to offer one free help to students.
- Group size: In most reported studies, group size ranges from three to six participants (Makri et al., 2021). A smaller group size promotes greater participation while a bigger group size hinders communication.
- Feedback: Feedback must be immediate. Conduct a debriefing session to provide students with an opportunity to self-assess and reflect on the game experience (Makri et al., 2021).
- Time constraint: Most studies have a duration of 45 or 60 minutes (Makri et al., 2021). The duration of the game depends on the duration of the class and the complexity of the puzzles. It is important to test out the escape room and allocate sufficient time as this affects students' self-assessment of whether they achieve the intended learning outcomes (Makri et al., 2021).

Implementation of Digital Escape Room

The students and the researcher met on Zoom and the game started with an introduction to the storyline (Figure 1). Students were informed that they were given 30 minutes to retrieve the locked item and they were offered one free help. The researcher then provided the hyperlink to the digital escape room (https://for.edu.sg/2sl4xy) in Zoom chat. Students were put into Zoom breakout rooms in teams of approximately five students randomly. Each team would appoint a leader to share screen so that everyone in the team worked on the same task. The researcher moved into the breakout rooms periodically to check that the students adhere to the rules of the escape room and to observe the students' interactions. Students in the breakout room could click on "Ask for Help" and the researcher would enter the breakout room to provide a tip to help the students with the tasks. The escape room consisted of four tasks: task A - balancing chemical equations, task B - calculating empirical formulas, task C - identifying the type of chemical bonding, and task D - interpreting element symbols (Figure 2-5). Students left the breakout room for the main room either when they have completed all four tasks in the digital escape room or when 30 minutes were up. At the end of the game, the researcher went through how to solve the tasks and conducted debrief. The total duration of the digital escape room including the debriefing was one hour.

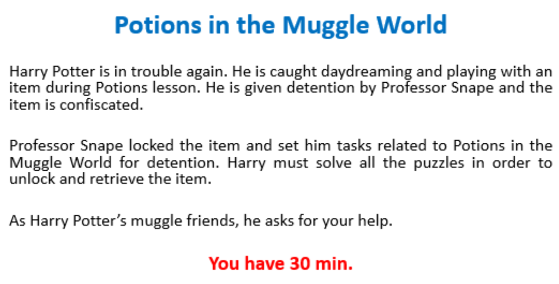


Figure 1. Harry Potter Themed Storyline.

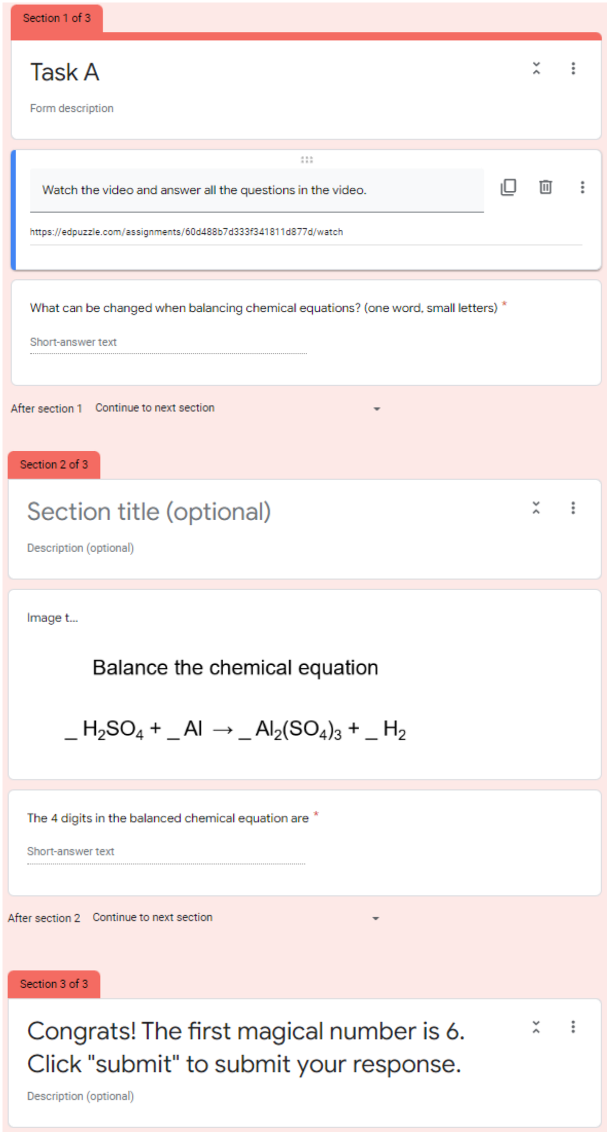


Figure 2. Task A – balancing chemical equations.

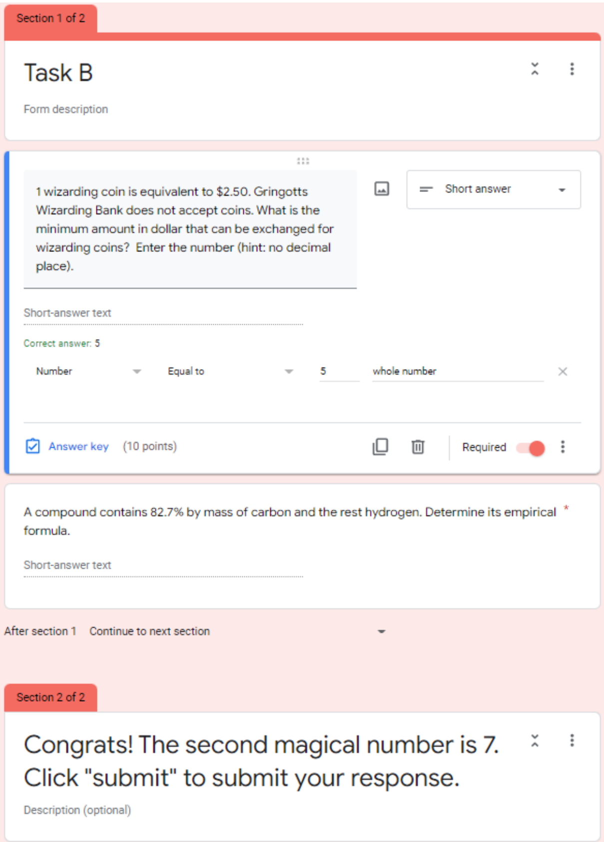


Figure 3. Task B - calculating empirical formulas.

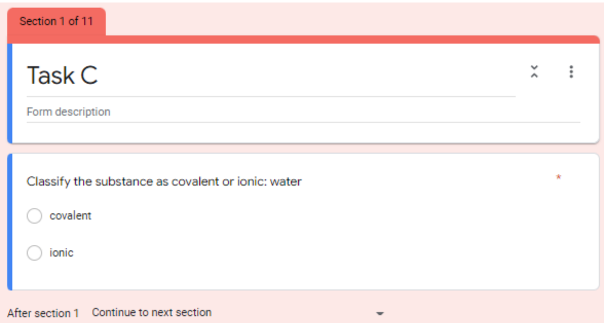


Figure 4. Task C – identifying the type of chemical bonding.

Figure 5. Task D – interpreting element symbols. Solve the jigsaw to reveal the hidden message.

The digital escape room was created using Google Slides and Google Forms. Google Forms were used to validate the students' responses to each task. Once a task was completed, students would enter their answers into the Google Forms. For every task solved successfully, a magical number would be revealed in the Google Form. If students enter an incorrect answer into the Google Form, a hint would be provided on the Google Form to guide them to the correct answer. When students solve all four tasks, they would obtain the four numbers needed to unlock the lock and retrieve the hidden item. The use of Google Forms in the creation of escape rooms is popular among educators for several reasons. Google Forms are free to use, easy to set up, and offer response validation which can be used to ensure the correct answer is entered (Vergne et al., 2020; Ang et al., 2020).

Research Design

Action research was conducted, and elements of both quantitative and qualitative research were incorporated into this study. The timeline of the study is shown in Figure 6.

Time	Group 1	Group 2	Group 3
July 2021	Pre-test was conducted		
Aug 2021	No lesson	Typical online lesson	Digital escape room
Sep 2021	Semestral vacation		
Oct 2021	Post-test was conducted		
	• Digital escape room • Typical online lesson • Survey	• Digital escape room • Survey	• Typical online lesson • Survey

Figure 6. Timeline of the study.

At the beginning of the study, a pre-test was conducted. Four topics (balancing chemical equations, calculating empirical formulas, identifying the type of chemical bonding, and interpreting element symbols) were tested in the pre-test. The pre-test score provided insights into the students' understanding of the topics.

Differentiated teaching methods were conducted for the three groups of students:

- one group was the control group where no additional teaching was done
- one group was taught through a typical online lesson with a collaborative learning method
- one group was taught through the digital escape room

Instead of quantitative research approach whereby the students are randomly sampled from the population, a quasi-experiment was conducted by using pre-existing classes. A typical class in NYP consists of 20 students.

The purpose of having a control group was to account for extraneous variables such as students maturing over time or students forgetting the concepts over time.

For the group that was taught through a typical online lesson with a collaborative learning method, the group and the researcher met on Zoom. Each student was given a word document with questions. The students were put into Zoom breakout rooms in teams of approximately 5 students randomly. They were given 30 minutes to discuss and attempt the questions as a team. Each team would appoint a leader to share screen so that everyone in the team worked on the same question. Students left the breakout room for the main room either when they have completed all the questions or when the 30 minutes were up. The team leaders would then present his/her group's answer. The researcher facilitated the session and went through the questions and answers presented. The duration of a typical online lesson with a collaborative learning method was one hour.

For the group that was taught through the digital escape room, the group and the researcher met on Zoom and the hyperlink to the digital escape rooms was shared in Zoom chat. The students were given 30 minutes to escape from the digital escape room and a debrief was conducted after the game. The total duration of the digital escape room including the debriefing was also one hour.

After the differentiated teaching methods were implemented in August 2021, the students went on a two-month semestral vacation during which no Chemistry lesson was conducted. A post-test was conducted for all three groups when a new semester began in October 2021 to evaluate whether students truly grasped the concept and overcame their misconceptions. The two-month semestral vacation provided sufficient time to test the retention of concepts and whether a change in the students' understandings had taken place. The scores obtained from three groups were compared and the researcher evaluated if teaching through a digital escape room resulted in better student performance compared to teaching through a typical online lesson with a collaborative learning method.

After the post-test was conducted, all students experienced the digital escape room and/or a typical online lesson. An anonymous survey was conducted to examine the students' perception of the digital escape room in comparison to a typical online lesson.

Results

38 PFP students participated in the study. Their pre-test scores for the four topics are listed in Table 1. Based on the scores, calculating empirical formulas was identified as the area of misconception among the students. Based on the students' answers, it was discovered that students had the misconception that mole ratios with decimal places should always be rounded off to the nearest whole number when calculating empirical formulas.

Table 1. Pre-test Score by Topic

Topic	Balancing chemical equations	Calculating empirical formula	Identifying the type of chemical bonding	Interpreting element symbol
Pre-test score	8.95 ± 2.64	6.05 ± 3.32	9.58 ± 1.69	8.97 ± 1.46
Max score = 10, n = 38				

The number of students from the three PFP classes who participated in the study were 11, 10 and 17 respectively. The pre-test and post-test scores of the three groups for the questions on calculating empirical formula are shown in Table 2. The large standard deviation could be attributed to different academic abilities among the students of different groups.

Table 2. Pre-test and post-test scores for calculating empirical formula

Group	1 n = 11	2 n = 10	3 n = 17
Pre-test	7.27 ± 3.44	5.50 ± 2.84	5.59 ± 3.48
Post-test	7.27 ± 4.10	6.00 ± 4.59	6.18 ± 4.16
Max score = 10			

Group 1 was selected to be the control group due to its higher average pre-test score. The purpose of having a control group was to account for extraneous variables such as students maturing over time or students forgetting the concepts over time. There was a two-month gap between the differentiated teaching methods and post-test to evaluate whether students truly grasp the concept and overcome their misconceptions. In addition, the researcher was curious to find out how much the students remember after they came back from their semestral vacation. The average post-test score was the same as the average pre-test score for group 1. Since no lesson was conducted for group 1 in the 3 months interval between pre-test and post-test, it was inferred that there was no significant gain or loss of concepts in the students over the period of three months with no lesson.

For groups 2 and 3, the average post-test score was about 10% higher than the average pre-test score. Hence, it is inferred that having some form of teaching was better than having no teaching at all. The pre-test and post-test scores for groups 2 and 3 were similar, so the score obtained from teaching through the digital escape room was similar to the score obtained from teaching through a typical online lesson with a collaborative learning method. This implies that a digital escape room is just as effective as a typical online lesson with a collaborative learning method in addressing misconceptions.

Survey

A survey on the student experience and perception of the digital escape room was conducted for all 38 students who participated in the study. The survey was conducted anonymously using Google Forms, and it consisted of open and closed-ended questions.

84% found the difficulty level of the puzzles just right, 13% found it too easy and 3% found it too difficult. 90% were able to complete the digital escape room within the time given of 30 minutes. Two groups asked for help and completed the digital escape room successfully with the help provided. Only one group could not complete the digital escape room as they were stuck with the jigsaw puzzle. Some students shared that they used the "Annotate" feature in Zoom to help them communicate and solve the jigsaw puzzle as a team.

95% of the students enjoyed participating in the digital escape room and 97% of them agreed that the escape room promotes teamwork. The students were also asked three questions on innovation competency. These questions were adapted from the FINCODA survey. Over 70% of the students agreed that participating in the digital escape room enhances their innovation competency (Figure 7).

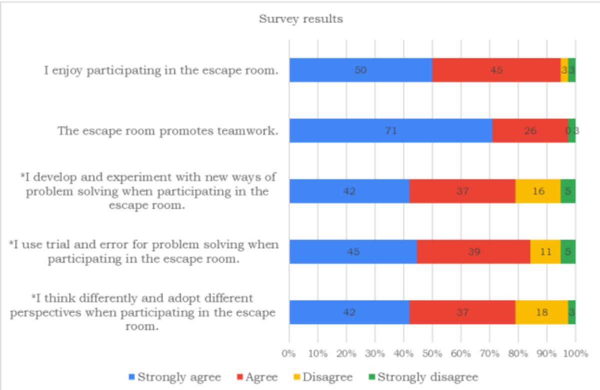


Figure 7. Survey on students' perception of the digital escape room. *Questions were adapted from the FINCODA survey which measures innovation competency.

Compared to a typical online lesson, more than 80% of the students found the digital escape room to be more interesting; they participated more actively and felt more motivated (Figure 8).

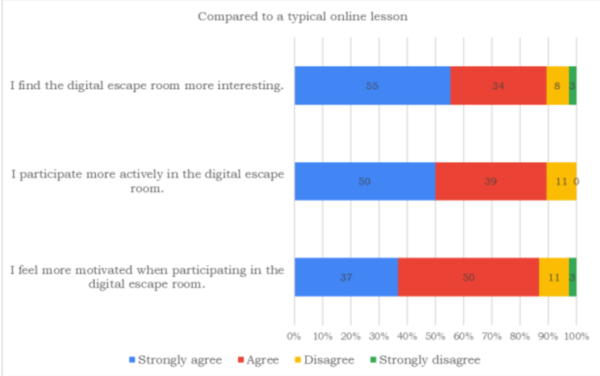


Figure 8. Survey on students' perception of the digital escape room compared to a typical online lesson.

Students also listed what they specifically liked about the digital escape room (Figure 9). Students expressed that they enjoyed the freedom when participating in the digital escape room. This escape room has an open structure, which means students could choose to solve the tasks in any order. Students enjoyed the freedom of working on any task, and they had the opportunity to hone their time management skills. If they were stuck in a particular task, they could move on and return to it later. This is unlike a typical lesson which is paced by the lecturer.

Figure 9. Word cloud on what students specifically liked about the escape room.

This research demonstrates that this digital escape room could promote teamwork, the ability to work under time pressure, communication skills, innovation competency, and increase student motivation.

Conclusion

This research shows that a digital escape room is just as effective as a typical online lesson with a collaborative learning method in addressing misconceptions. Teaching through a digital escape room has the additional benefits of enhancing soft skills. This research demonstrates that this digital escape room could promote teamwork, the ability to work under time pressure, communication skills, innovation competency, and increase student motivation. The researcher recommends the use of a digital escape room to complement typical lessons for these additional benefits.

Limitations

The topics covered in this study were not exhaustive as the students selected for this study were under the foundation program. These four topics were chosen as they would not be tested again in the foundation program. Hence, students who chose not to participate in this study would not be at a disadvantage. As the effectiveness of digital escape rooms in addressing misconceptions in Chemistry has not been established prior to this study, this study was not part of the curriculum. As the study was conducted outside curriculum hours, fewer students participated because they had other commitments.

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AN INVESTIGATION INTO STUDENT AND EDUCATOR ATTITUDES AND PERCEPTION TOWARDS THE INTEGRATION OF AI TUTOR AND MARKER IN NURSING EDUCATION

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Abstract

The pandemic has accelerated the adoption of technology-enabled learning in many educational institutes to support students' learning. Artificial Intelligence (AI) has become more evident in online learning (Kim et al., 2020; Iles, 2019; Shen & Shu, 2020). In response to COVID-19 measures, the Diploma in Nursing (NSG) from the School of Health Sciences (HS) at Ngee Ann Polytechnic leveraged on AI-based learning solutions, such as AI tutor and AI marker, for teaching and learning. The AI tutor provides immediate answers to students' common queries pertaining to the modules which tend to recur every semester. The AI marker grades and provides immediate feedback to students on their responses in short answer questions. These AI-enabled systems are accessible anytime and anywhere. They also free up educators to focus on educating their students and improving students' learning experience.

While there is ample research relating to the contributions of AI to student learning (Kim et al., 2020; Iles, 2019), there seems to be limited research from the students' and educators' perspectives on the use of AI and its ethical considerations. This study aims to provide new insights into tertiary nursing students' and educators' perceptions, as well as attitudes toward the integration of AI in Education. An online survey was constructed based on past literature (Joshi et al., 2021; Kim et al., 2020) to measure nursing students' and educators' perceived benefits and attitudes towards AI tutor and marker. The survey was administered to Year Two and Three nursing students and educators from the Diploma in Nursing in July 2021. The analysis focused on the students' and educators' perceptions of the usefulness of AI in nursing education and highlighted similarities and differences in their perceptions. The study showed that students' attitudes and perceptions towards AI in Education are positive. Faculty's attitudes and perceptions towards AI in Education are higher as compared to students. Both students and faculty valued fairness and protection of their personal data in the use of AI. The findings added new insights into tertiary nursing students' and educators' perceptions and attitudes toward the integration of AI in Education.

Keywords: *Artificial intelligence, nursing education, technology-enabled learning, smart learning solution, AI tutor, AI marker, AI ethics*

Introduction

The COVID-19 pandemic had caused global disruption to almost every sector (Goh et al., 2020). When the outbreak first occurred in early 2020, it had impacted education significantly. To ensure education continuity during the pandemic, schools were forced to shift their face-to-face teaching to online. Such measures have required adjustment by both educators and students, for example, educators had to explore useful tools for teaching and students had to adapt to new ways of learning (Pantelimon et al., 2021).

Artificial Intelligence (AI) represents a potential way to support students' learning and improve educational outcomes (Remian, 2019). Artificial intelligence is one of the tools that were explored to support students' learning when restrictions limited face-to-face learning. For instance, AI offers customized learning, provides dynamic assessments, facilitates "meaningful interactions in online, mobile or blended learning experiences" (Zhang & Aslan, 2021, p. 1) as well as allows schools to streamline administrative work so that educators have more time to handle complex tasks which machines are incapable of resolving (Marr, 2020). AI refers to the science and engineering of making intelligent machines, especially intelligent computer programs, and is related to the similar task of using computers to understand human intelligence (McCarthy, 2004).

Applications of AI in School of Health Sciences, Ngee Ann Polytechnic

In April 2020, when Singapore implemented the Circuit Breaker measures – educational institutions had to close their campus for nearly two months, and students shifted to full home-based learning (The Straits Times, 2020). The rapid transition from face-to-face to online learning posed challenges to both educators and students in the School of Health Sciences at Ngee Ann Polytechnic. For example, during the full home-based learning (HBL), lecturers were not able to provide hands-on guidance on students' practical skills which are essential for their practice. In addition, the teach-to the-middle instruction, which was widely used in pre-recorded lectures, was unable to address the needs of learners who differed significantly from the norm.

To address these challenges, the Diploma in Nursing (NSG) leveraged on AI-based learning solutions, such as AI tutor and AI marker, for teaching and learning. AI was adopted because it could help to facilitate personalized learning and empower learners especially during HBL when students may require more support from their lecturers when the learning experience is so different from the past. In addition, AI can increase the efficiency of certain tasks such as answering frequently asked queries which can take up much time.

AI Tutor & AI Marker

Nursing students tend to be kinesthetic learners who prefer a "hands-on" approach to learning. They require more support from lecturers when learning theoretical concepts and may also be less able to express their learning during written tests and examinations. However, the work processes of grading and marking assessment is labor intensive, repetitive and time consuming.

Prior to Circuit breaker, the school had started the development of the AI tutor and AI Marker projects but on a small scale. The restrictions brought about by the pandemic led to the increase adoption of the use of AI to fill the gaps in teaching and learning. With the move to home-based learning there was pressure for the lecturers to monitor students' learning progress, to support learning challenges and to provide feedback for improvement. This was especially difficult for a large cohort of 600 nursing students. Hence, AI was explored as a ready option to provide additional support in students' learning.

There are 2 AI bots that were implemented in the Diploma – AI Tutor & AI Marker.

(1) AI Tutor
The AI Tutor aims to supplement students' learning during COVID-19 pandemic. With the move to home-based learning (HBL) in response to the pandemic, the face-to-face lectures have been converted to recorded lectures for students to learn asynchronously at their own pace and find answers on their own. When students have difficulty in understanding the topic, they may not be able to seek clarification immediately as their lecturers may not be available to answer their queries. With the AI Tutor, students can seek clarification anytime, as the bot plays the role of a teaching assistant providing them additional resources that would enable understanding and allowing students to progress in their learning. Studies have also shown that students understand content better at their preferred time of the day (Callan, 1997). With the intelligent tutoring system, the turnaround time for the responses to students' queries was reduced significantly from a maximum of two days to instant replies.

The AI tutor was developed to allow for differentiated tutoring flow. The bot first assesses students' understanding and delivers individually customized tutoring flow and resources to address the unique needs of each learner. There is also a post tutoring quiz that allow students to monitor their own learning progress and helps the lecturers monitor learning via the tutoring flow.

In the knowledge base created by the lecturer, the answers to the questions were refined by the lecturers to suit the learning ability of each type of learner. To cater to the different visual, auditory and kinesthetic learning styles of learners, videos, pop quizzes and fun facts were also injected within the tutoring flow to more actively engage the learners.

The AI tutor also frees lecturers from handling frequently asked questions pertaining to the module which recurred every semester. The long hours spent answering these queries, conducting remedial and revision per semester could be reduced and channeled to more complex issues relating to teaching and learning.

(2) AI Marker
The AI Marker was designed to digitalize paper-based mock assessments using AI-based learning solution. By leveraging on AI machine learning algorithm, the students have more non-graded practice exercises and the flexibility to learn at their own pace. In addition, time saved by lecturers on marking mock assessments could be used more effectively to design enriching learning experiences for students - Students who attempted past years' examination questions would be auto auto-marked by the bot and recommended answers with additional resources would be provided for students' reference and learning. The time taken ~~by the AI Marker~~ to provide feedback to students is significantly reduced as the AI Marker provides instant and timely individualized feedback, thus resulting in fast turnaround time.

Need for the Study

While there was ample research relating to the effectiveness of AI to students' learning, there seems to be limited research from the educator's and students' perspectives on the use of AI and its ethical considerations. This study will explore the attitudes and perceptions of tertiary educators and students toward the integration of AI in Education.

The main research questions for this study are:

1. What are the attitudes, perceptions and ethical considerations of students towards the use of AI Tutor and AI Marker in education?
2. What are the attitudes, perceptions and ethical considerations of educators towards the use of AI Tutor and Marker in education?
3. What are the ethical considerations of using AI in education?

The results of this study will provide some groundwork for further understanding the relationships, thus contributing to the existing body of knowledge about the perceptions of educators and students on the usefulness of AI in education and its ethical considerations, especially in the local Singaporean educational context. Besides, the study may also provide invaluable insights for different groups of people, such as educators, instructional designers, educational policy makers and educational researchers on how AI in education can be implemented.

Research Participants

One thousand two hundred Year 2 and Year 3 nursing students, and 10 educators who have used the AI bots for teaching and learning of Human Bioscience and Nursing Science modules in the October 2022 semester were invited to participate in a survey to assess the attitudes, perceptions and ethical considerations towards the use of AI in education.

Research Method

This is a descriptive research design with convenience sampling method.

There were separate surveys for students and educators. The survey links were created as Google forms and the links were sent via email to the participants. The survey period was four weeks. Eventually, only 141 responses from students and 7 responses from educators were valid.

The research instrument was a questionnaire developed based on past literature findings from Joshi, Rambola & Churi, 2021; Kim, Merrill, Xu & Sellnow, 2020. The questionnaire consisted of four parts:

Part 1: Demographic data and experience with AI Tutor and AI Marker
Part 2: Attitudes
Part 3: Perceptions
Part 4: Ethical considerations

Questions in part 2 to 4 utilized a 5-Point Likert scale (with 1 being strongly disagree and 5 being strongly agree) and two open response items to examine the ethical considerations of students and educators.

Results and Discussion

The study commenced in May 2021 and concluded in Oct 2021. Analysis of the survey results were based on valid responses (Table 1) by students (n=141) and educators (n=7).

Criteria	Students	Educators
Gender ratios	78% Female	86% Female
Mean age of participants (Years)	20.4	47.3
Experience with AI tutor	53%	43%
Experience with AI Marker	47%	57%

Table 1: Profile of students and educators

Overall Observations

The results from the survey for students and educators on attitudes about the use of AI in the teaching and learning experience were highly positive (Table 2). Educators expressed a higher level of positivity than students as the smart learning solution helps to address students' frequently answered questions on the go and not dependent on the availability of the educators. There may be grounds to investigate further the reason for the higher rating from educators.

Attitudes	Students (n = 141)	Educators (n = 7)
Enjoyed using AI tutor/marker	3.59 (0.85)	4.29 (0.49)
Felt comfortable using AI tutor/marker	3.67 (0.82)	4.43 (0.54)
AI tutor/marker was easy to use	3.80 (0.76)	4.71 (0.49)
Would like to use AI tutor/marker in other modules	3.48 (1.00)	4.43 (0.54)
AI tutor/marker allowed flexibility in learning schedule	3.72 (0.93)	4.29 (0.76)

Table 2: Mean (standard deviation) ratings on attitudes of students and educators on the use of AI Tutor and AI Marker in education

The attitude on AI Tutor/Marker (Table 2) that it was easy to use had the highest mean rating of 3.80 in students while students were not as keen to use the AI tutor/Marker in another module (3.48). This meant that ease of use may not necessarily be a key consideration when students are selecting a tool to support their learning. It is also noted that the question on usage of AI Tutor/Marker in other modules also had the biggest difference in rating between students and educators compared to the other questions indicating that students may not be as comfortable with the AI tools as the educators (Table 2). It is also observed that educators are much more comfortable in using AI tools than students (4.43 vs 3.67). This difference in ratings may suggests that from the lecturers' lens, the use of AI tools decreases their workload, and thus are more in favor than students to use AI tools in other modules. However, from the students' lens, they may perceive that AI tools lack the human touch, and thus are not in favor to use AI tools in other modules, which is an area that can be further investigated to enhance the learning experience for students when using AI tools in future.

Some of the advantages with AI Tutor/Marker shared by students and educators include convenience, fast answer, efficiency, provided flexibility and students were able to learn at their own pace. Students would prefer more explanation, interaction with lecturers and more coverage of syllabus.

Perceptions	Students (n = 141)	Educators (n = 7)
The use of AI tutor/marker improved students' learning.	3.57 (0.84)	3.86 (0.90)
The use of AI tutor/marker helped students learn the class content.	3.72 (0.82)	4.00 (1.00)
The use of AI tutor/marker helped students develop confidence in the module.	3.57 (0.83)	3.86 (0.90)

Table 3: Mean (standard deviation) ratings on perceptions of students and educators on the use of AI Tutor and AI Marker in education

Among the three aspects of the use of AI Tutor/Marker that is investigated, students and educators seemed to have the "closest" sentiment in their "Perception" on the use of AI in learning, even though educators' ratings were still a little higher than students (Table 3). From the rating, both students and educators were in close agreement that the AI Tutor/Marker have improved learning and allowed students to be more confident about their learning in the modules. Going forward, the authors may want to investigate further the specific aspects of the AI Tutor/Marker that have contributed to the positive learning experience.

Ethical considerations	Students (n = 141)	Educators (n = 7)
The use of AI reflects the objectives of these principles: transparent, fair and explainable.	3.71 (0.75)	4.57 (0.54)
The protection of the interests of humans should be primary considerations in the design, development and deployment of AI.	3.72 (0.75)	4.71 (0.49)
AI providers are responsible and accountable for the proper functioning of AI systems and for the respect of AI ethics and principles.	3.77 (0.68)	4.57 (0.54)
AI providers identify, log, and articulate sources of error and uncertainty throughout the algorithm and its data sources so that expected and worst-case implications can be understood and can inform mitigation procedures.	3.74 (0.74)	4.29 (0.49)
Third parties can probe, understand, and review the behavior of the algorithm through disclosure of information that enables monitoring, checking or criticism.	3.72 (0.75)	4.29 (0.49)
Automated and algorithmic decisions and any associated data driving those decisions can be explained to users in non-technical terms.	3.78 (0.77)	4.29 (0.49)

Table 4: Mean (standard deviation) ratings on ethical considerations of students and educators on the use of AI in education

Educators had higher mean ratings in ethical considerations on the use of AI in education than students (Table 4). Students were generally confident that the AI Tutor/Marker was transparent, accountable and responsible in that the AI decision making process can be easily explained and understood. Their average rating for all questions in this set has a deviation of 0.7. For educators, their level of "trust" and "confidence" in the AI Tutor/Marker was even higher as the average rating for the questions in this set is 4.45 – higher than "Attitude" and "Perception" indicating strong confidence and trust in the AI Tutor/Marker to make the correct "decisions" to support students' learning.

User experience

Both AI tutor and marker have the automatic feedback function. Before the students ended the AI tutor or marker session, they would be asked to rate their learning experience. Feedback from the students helped

lecturers to find the gaps in their teaching efforts and do better. With the feedback garnered, the lecturers could continuously refine the solution to enhance students' learning. The average rating on the AI marker provided by the students after their AI marking session was also positive at 4.3 out of 5. The feedback garnered on the use of AI tutor was favorable with a rating of 4.2 out of 5. From the qualitative feedback, the students found the tool awesome, and some suggested it to be deployed in other modules.

The Module Experience Survey (MES) is an institutional end of semester survey on students' learning experience in the module. The module experience survey ratings for the modules with AI tutor and marker were much higher as compared to the institution level and comparable with the school level as shown in Table 5a. The MES for Nursing Science 1 (NS1) module with AI marker was much higher as compared with previous semester without AI marker (Table 5b). The pass rate for common test and exam for modules with AI tutor and marker were also higher as compared to the previous semester without the implementation of AI tutor and marker (Table 5c). These data are consistent with the positive survey results from the students who found the application and its impact on their learning positive.

Table 5a: MES ratings for module with AI Tutor and marker as compared to institution and school level:

Semester 1	Q1 - S&K	Q2 - Thinking	Q3 - T&L	Q4 - Feedback	Q5 - Materials	Q6 - Activities	Q7 - Overall
Institution level 21/22 S1	5.11	5.10	5.07	5.00	5.04	5.05	5.06
School level 21/22 S1	5.28	5.24	5.25	5.19	5.22	5.23	5.24
HBS1.1 Module with AI tutor	**5.37**	**5.30**	**5.27**	**5.00**	**5.23**	**5.29**	**5.28**
INS2.1 Module with AI marker	**5.34**	**5.36**	**5.21**	**5.20**	**5.19**	**5.29**	**5.24**
NS5 Module with AI marker	**5.39**	**5.42**	**5.36**	**5.33**	**5.31**	**5.34**	**5.33**

Table 5b MES ratings before and after AI marker:

Course	Q1	Q2	Q3	Q4	Q5	Q6	Q7 Overall
NS1 19/20 S2 (Before AI marker)	**5.18**	**5.18**	**5.18**	**5.08**	**5.15**	**5.14**	**5.19**
NS1 20/21 S2 (After AI marker)	**5.29**	**5.34**	**5.25**	**5.24**	**5.12**	**5.21**	**5.20**

The details of Q1 to Q7 are given below:

S/N	**Survey Questions**
Q1	The module helped me to develop useful skills and knowledge
Q2	This module stretches my thinking
Q3	The teaching and learning approaches are appropriate for this module/project
Q4	I received useful feedback in a group/individually on my progress in this module/project/internship
Q5	The module materials (including materials on MeL and other online platforms) helped me understand the content of the module.
Q6	The module activities enhanced my overall learning
Q7	Overall, this module provided a good learning experience

Table 5c: Exam and common test pass rates before and after AI tutor and AI marker:

HBS1	Total active students	Exam PASS RATE (%)	Exam MEDIAN (marks)
Exam 2020 **(Before AI tutor)**	529	69	61
Exam 2021 **(After AI tutor)**	470	92.77	79

Semester/ Year	Total students	NS1 Exam PASS RATE (%)	NS1 Exam MEDIAN (marks)	NS1 Overall pass rate (%)
Semester 2/2019 **(Before AI marker)**	301	80.07	59	99.34
		* NS1 EoSCT PASS RATE	*NS1 EoSCT MEDIAN	NS1 Overall pass rate (%)
Semester 2/2020 **(After AI marker)**	309	94.5	84	100

* EoSCT denotes end of semester common test. The change to assessment component was due to COVID-19.

Attitudes and Perceptions towards AI in Education: Benchmarking with other studies

- The study showed that students' and educators' attitudes and perceptions towards AI in Education were generally positive, as reflected in Table 3:Student perception survey score of 3.57 out of 5;,
- Educator perception survey score of 3.86 out of 5.

The user experiences with AI tutor and marker were also favorable. This was consistent with the findings of the study by Halimah et al. (2018) and Treceño-Fernández et al. (2020). Similarly, studies by Wu et al. (2020) also showed that the integration of AI in education has yielded satisfactory experience for the students. This may be explained by the benefits of AI, which includes the following:

- Instant feedback
- Provision of post-assessment scores with recommended answers
- Additional resources in text and video formats
- Flexibility of practicing anytime and anywhere

Faculty's attitudes and perceptions towards AI in Education were higher as compared to the students. This was inconsistent with the study by Aljohani (2021) which revealed that students were more likely than educators to agree that AI supports learning. Similarly, in the study by Kennedy (2016), there was a general openness to using social robots in education, although education professionals might approach this with a degree of caution.

The favorable attitude and perception of the faculty may be attributed to productivity savings in AI. Each student is expected to spend 8 hours per semester with the AI Marker prior to high stake assessments. The projected productivity savings with the marking of mock assessments for 16 tutorial groups amounts to $19,200 for the first year. The total productivity savings for five years will be $480,000. The net savings and earnings after deducting the life cycle of the AI Marker is $300,000. With the bot trained to include one additional module per semester, the time spent for a 5-year period translates to another 576,000 hours which will benefit 7,200 students. The same applies to AI tutor, which generates considerable time saved, translates to man-hours and better cost effectiveness.

Ethical Considerations towards AI in Education

Despite the benefits yield from AI-infused education programme, the faculty must be cautious of the ethical considerations involved. This ethical concern has also surfaced as one of the students' main concerns during the student survey.

To reassure the various stakeholders on ethical considerations, it is essential that the following points are addressed:

- Transparency on process of machine learning
- Knowledge of algorithms involved in the AI bot
- Confidentiality of students' identity
- Non-discrimination of poor performing students (fair and unbiased)

These points were also discussed and supported by Akgun & Greenhow (2021), which are valuable considerations for an institution, when considering the adoption of AI into education.

Conclusions

The results of this study provide insight on the perceptions of educators and students on the usefulness of AI in education and its ethical considerations, especially in the local Singaporean educational context. Future work can gear towards exploring randomised controlled trial comparing the pre- and post-tests of AI assisted group with conventional learning group and larger sample size for future studies.

With the successful implementation of AI tutor and Marker for few consecutive runs, an area of enhancement is the accuracy of the AI Marker. Taking into cognizant that there are many different alternative answers and writing styles, the development team continues to monitor and train the bot to improve the model.

The AI Tutor and marker, being the first of its kind in Ngee Ann Polytechnic puts the institute at the forefront of AI in Education. With AI powered learning solutions, education will become more personalized and scalable to varied aptitude of learners in the future.

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Teaching and Grading Team Programming Skills Using a Code Sharing Platform: A Case Study of Cloud Application Development

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Abstract

This paper presents a case study of our Project-Based Learning (PBL) classroom using GitHub. The students' projects aim to develop a web application that interacts with the Internet of Things (IoT) devices to solve an authentic and real-world problem. We first describe skills needed in team programming and the roles of GitHub, the industry-standard code sharing platform. We then present what the students learn through our PBL classroom, including the architecture of modern cloud applications. Next, the course outline of the PBL classroom is presented. Our PBL classroom has provided introductory hands-on lectures and group work for 15 weeks (45 hours total). Finally, we present examples of projects that the students considered interesting and valuable. After the PBL classroom, we analyzed the student behavior using an analytics tool provided by GitHub. The results of the student survey are then presented. Students of 90% answered that the experience of team programming using GitHub would help their future carrier. However, students of 61% felt the use of the history of GitHub in grades negatively.

Keywords: *GitHub, Git, Version Control, Project-Based Learning, Cloud Application Development*

Introduction

Many modern industrial products are connected to the Internet; the products are integrated with cloud-based applications and the Internet of Things (IoT) devices to enhance the product values. Therefore, almost everything we teach in technical institutions today has been related to some cloud-based software development. On the other hand, with the advent of code-sharing platforms, such as GitHub, engineers have required team programming skills using such online code-sharing platforms. GitHub, the industry-standard code-sharing platform, allows software developers to share source code, exchange ideas, review and test code, and collaborate with team members online. Thus, this paper presents the case study of our PBL classroom that includes two essential skills: the development of modern cloud applications and team programming using GitHub.

Literature Review

Feliciano et al. examined how the use of GitHub in the project-based software engineering courses benefits students (Feliciano et al., 2016). Their student survey showed that the benefits include gaining industry-relevant skills and practices, encouraging student contributions to course content, and version-controlled assignments for providing instructor feedback. In addition, they reported that the ability to see others' work through GitHub encouraged students' collaboration. Francese et al. reported using GitHub in their PBL classroom for mobile application development (Francese et al., 2015). They measured teams' metrics obtained from GitHub, including the number of checkouts, lines of code, and work distribution by day of week and time of day deduced from user's activities in GitHub. Tushev et al. reported the results of a case study on using GitHub to facilitate student collaboration and evaluation in software engineering class projects (Tushev et al., 2020). Their results showed that enforcing GitHub in projects can help students learn about online version control platforms without impacting the quality of their work. However, they concluded that the students' activities on GitHub (e.g., the number of *commits*) cannot be used as reliable metrics for grading team projects.

While the use of GitHub in the programming and PBL classroom is not unique, in this paper, we would like to share insight through our experience in the PBL classroom for cloud application development. Moreover, this paper reports the correlation between the students' behavior on GitHub and team grades. Sprint and Conti analyzed the number of *commits* in their classroom. They found that there is a weak correlation between behavior on GitHub and grades at the group level, but individual students exhibited strong correlations (Sprint and Conti, 2019). While they analyzed the experimental results in the CS1 course (i.e., introduction to programming courses defined by the ACM Computing Curricula), iOS application development course, and data mining course, we present an analysis of the students' behavior in cloud application development.

Contribution of This Paper

The purpose of this paper is to share the experience in the use of GitHub in our Project-Based Learning (PBL) classroom for cloud application development. Since our curriculum does not include a version control system (Git) yet, we present a method that combines introductory hands-on lectures and group work in 15 weeks. In addition, we show an analysis of the students' behavior on GitHub and an exit student survey.

Importance of Team Programming – Application of GitHub in Education

We first describe why students in software engineering courses need to learn the code-sharing platform. A code-sharing platform is a version control system with a collaboration website. Team programming in the PBL classroom involves writing code with team members and maintaining all the program files in the project. The essential role of version control systems (VCS) is to track changes to program files and to share all the files with members while enhancing collaboration.

Git has become an industry-standard VCS in the last decade. Git stores all the project files in *repositories* and tracks changes to the files by *commit* operation. The *repository* is the place all files of the project are stored. The *commit* is an operation to add the code changes to the repository; the operation records who and when changes the code. Git provides the *branch* and *merge* operations in addition to the essential change tracking function. The *branch* and *merge* functions of Git enable team members to create a complete copy of the main branch; they can test any changes on the test branches without affecting the *main* branch. If a member is satisfied with his or her code changes in the test branch, he or she can *merge* them into the *main* branch. The *branch* and *merge* operations enable team members to contribute their effort to the shared project files. The *branch* and *merge* functions of Git, thus, are vital for developing active and creative collaboration.

Furthermore, Git provides a sharing method of files between team members. A *remote repository* is a set of shared files of a project on a remote server. The team members can *push* their code changes on their computer's local repository to the *remote repository*. The program files are shared via the *remote repository*. Any member can *pull* the code changes in the *remote repository* to update his or her *local repository* to the latest version.

Although the version control system of Git provides essential functions, it does not provide a complete collaboration environment. GitHub is a hugely popular collaboration platform in the industry that provides hosting services for *remote repositories* and additional services for supporting the collaboration in team programming. Figure 1 shows the relationship between Git, GitHub, and GitHub Classroom. GitHub is the industry-leading code-sharing platform; it has over 73 million developers and hosts over 200 million repositories (GitHub, n.d.).

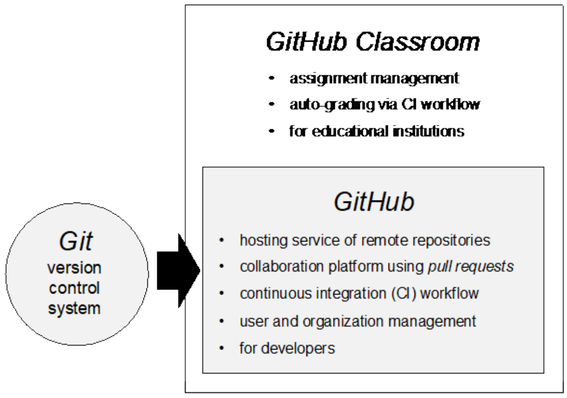

Figure 1. Relationship between Git, GitHub, and GitHub Classroom

From the online collaboration platform perspective, the critical function of GitHub is the *pull* request mechanism (Tu et al., 2022). When a member *pushes* the code changes to the *remote repository*, he or she issues a *pull request* on the GitHub website. The *pull request* asks the maintainer (e.g., a project leader) to *pull* the proposed changes on his or her *local repository*. The maintainer then performs a code review to check whether the proposed code changes can be accepted. When the code change is not accepted, the maintainer requests further improvement to the member using the messaging function of GitHub. Finally, the maintainer *merges* the accepted code changes into the *remote repository* using the GitHub website.

Another critical service of GitHub is GitHub *Actions*; the service enables a user's continuous integration (CI) workflow. For example, when *pushing* new *commits* on a *remote repository*, a pre-defined workflow can compile and run tests over the new code. The GitHub *Actions* are also used in GitHub Classroom, the extended GitHub platform that supports assignment management for instructors in educational institutions (GitHub Classroom, n.d.). GitHub Classroom provides auto-grading functions to instructors by using a pre-defined continuous integration workflow. The code submitted by students is automatically compiled and tested (e.g., input and output test) to grade.

When instructors use GitHub in the classroom, they can adopt two approaches: the first approach is using GitHub as is. The second approach is using the GitHub Classroom. We adopted the former approach. Using GitHub in the classroom allows students to learn the industry-standard tool. Many instructors, an estimated 18,000 educators, have implemented Git and GitHub in their classrooms to make students more competitive in the job market (Hsing and Gennarelli, 2019).

What Student Learn in our PBL classroom: Modern Cloud Application Development

This paper presents a case study of the PBL course for cloud application development. The many modern cloud architectures, sometimes called Multi-access Edge Computing or Fog Computing, consist of the following

three components at the different locations (Ren et al., 2019): (1) end-device such as mobile phones and Internet-of-Things (IoT) devices with limited computing resources, (2) edge servers located between end-devices and central cloud servers; the edge servers provide additional computing resources to the end-devices with low-latency, and (3) cloud servers located in public cloud data centers (e.g., Amazon Web Services, Google Cloud Platform, and Microsoft Azure). For example, European telecom companies propose the Multi-access Edge Computing (MEC) architecture. The edge server is connected to a base station of a 5G network to provide low-latency computing resources to mobile phone users. However, the instructor in the educational institution cannot change the public base station of cellular networks for student experiments. Therefore, we instead place our private edge servers in our college network to provide low-latency computing resources.

Outline of Our PBL Course

The number of students in the PBL classroom in 2021 was 53, and the number of teams was 11 (i.e., the team consists of five or four students). They are in the 4th year in the Japanese KOSEN engineering education system (i.e., the same age as the 1st year university students). They have studied programming languages such as C and Python for three years and digital circuit design for two years. However, they have not received any lecture on team programming using GitHub. The PBL classroom provides lectures and group work for 15 weeks (45 hours total). In the first half of the classroom (seven weeks), the students study technical skills through hands-on lectures. In the last half of the classroom (eight weeks), the students plan, design, develop, and deploy the proposed system (Figure 2). They present their contribution in the final demonstration session in the classroom. They also present their contribution on the open day of our college.

Figure 3 shows the overview of cloud application development in the PBL classroom. A cloud application consists of three systems: Internet of Things (IoT) devices, edge servers, and public cloud. For example, an IoT device detects the movement of a human being, takes the photo, records a voice command, and sends the photo and the voice to the edge server. A web application on the edge server, for example, displays the list of the recent photos on a user's smartphone and responds to the voice command. Public cloud services can enhance the functionality of a web application on the edge server if necessary. Such functionalities may include face and voice recognition, language translation, and mapping the location in Google Map. When an IoT device receives a response from an edge server, it may play the voice message via speakers. The three components seamlessly interact via communication channels such as campus Wi-Fi and the Internet connection. The team members must develop at least two applications: a program for IoT devices and a web application on an edge server. The web application is responsible for interacting with IoT devices.

Figure 2. Students in our PBL classroom

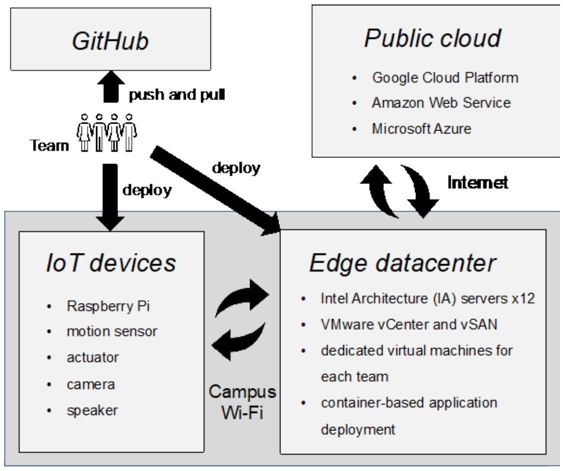

Figure 3. Overview of the cloud application development in our PBL classroom

Student Projects – Interest and Value

A good project is designed to solve an authentic problem, increasing the student's interest. In addition, such a project can enhance a deep understanding of knowledge obtained from lectures. The appropriate problem drives students' activities, for example, formulating plans, tracking progress, and evaluating the solution (Blumenfeld et al., 1991). In our PBL classroom, students decide their project goal; most students choose a problem they believe is interesting and valuable.

A team, for example, developed an IoT device and a web application that displays the availability of washing machines in the college dormitory. The developed IoT device has an image recognition function to check the status of the LED on the washing machine. Another team developed a system to save energy on lighting by using motion sensors. However, half of the student projects do not use IoT devices effectively. Such projects usually use only the speaker of IoT devices to play voice messages or sounds. Many students can easily design and develop a web application because they are familiar with it on their smartphones. The teacher may need to describe the example usage of the IoT applications around students, such as smart home and security, smart agriculture, and smart healthcare devices.

Details of Introductory Hands-on Lectures

In doing projects, students need to use many tool skills necessary to undertake the project. The skills include developing a web application and an IoT device, sharing code using GitHub, setting up an edge server, and deploying a web application using virtualization and container technology. However, many students have no experience in the above tool skills until this PBL classroom. Therefore, the instructor gives the introductory hands-on lectures to study the above skills in the first half of the 15 weeks (7 weeks; about 21 hours in total).

The students first set up an edge server; they install a hypervisor (VMware vSphere) in each team's server. A hypervisor is a software to virtualize the physical hardware resources into logical resources; it is used to construct an Infrastructure-as-a-Service (IaaS) cloud. All the 11 edge servers are controlled using VMware vCenter and VMware vSAN as a single private edge cloud data center. Next, each team creates and runs its virtual machine on the private edge cloud. Finally, they install operating systems and set up network configurations. This hands-on lecture gives students the first experience building the private cloud infrastructure.

The next step of the hands-on lecture is to study web application development using Java programming language using an integrated development environment (Eclipse) as follows: (1) they develop sample web applications using Jakarta Enterprise Edition (f.k.a., Java EE) libraries and learn the database technology, including relational database management systems and Structured Query Language (SQL). (2) the student studies the development of an IoT device using a Raspberry Pi computer with sensors, a camera, speaker, and actuator, and (3) they learn how to deploy web applications using container technology (i.e., Docker).

Finally, the student learns how to use GitHub for team programming. The lecturer creates *Organization* and invites students to *Team* on GitHub. Each team creates its project *remote repository* on GitHub to share the project code. In the hands-on lecture, the students first *clone* the *repository*, *commit* each member's changes, and *push* the changes to the *remote repository* on GitHub. The students perform all the Git operations using the Eclipse plugin. Our hands-on lecture for Git includes the resolution of *merge conflict* when the members push changes in the same code simultaneously.

Monitoring the Projects using GitHub Dashboard

Each team first writes the specification document of the proposed system. Each team then creates the Gantt chart that visualizes sub-tasks and assignees to make the schedule. After that, each team maintains the project *repository* on GitHub to share their code during the last half of the class period of 15 weeks (8 weeks, 24 hours in total). The instructors can track the student's contribution to his or her team, such as the number of *commits* (i.e., updates of source code) and the contents of added code,

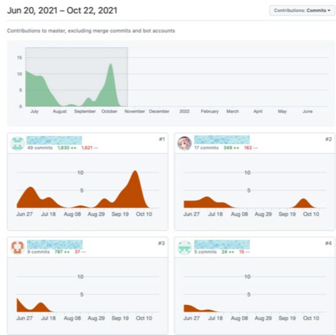

Figure 4. The graphs of each member's *commits* during the project period (GitHub *Insights* dashboard)

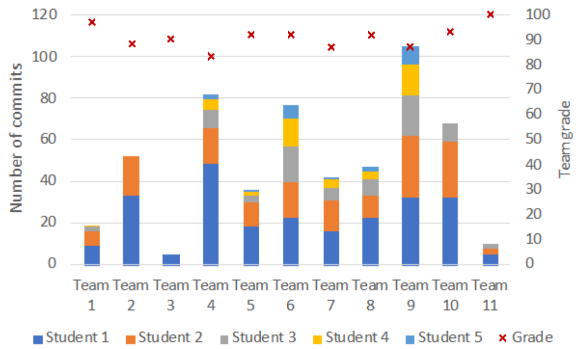

Figure 5. The number of *commits* and team grade

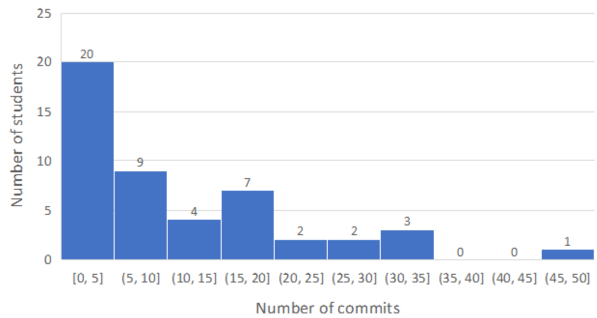

Figure 6. Histogram of number of *commits* per student

through a web-based GitHub dashboard. GitHub *Insights*, for example, is a tool to track the users (i.e., the students in the classroom) using metrics such as the number of *commits* and the added lines of code. Figure 4 shows each member's contributions using the GitHub *Insights*. While the graph on the top shows the changes in the total number of *commits* (i.e., the frequency of the code update), the four graphs below show the number of each member's *commits*. These graphs clearly show how each member contributes to the project.

Analysis of Commits Behavior and Team Grades

We analyzed the student's *commit* behavior using the GitHub *Insights* dashboard after the end of the project. Figure 5 shows the number of *commits* of the 11 teams with team grades, and Figure 6 shows the histogram. The median of each student's *commits* was 8.5, and its average was 11.3. The median of the total number of

team *commits* was 47, and its average was 49. On the other hand, Figure 7 shows each student's line of code for the project, and Figure 8 shows the histogram. The lines of code were not proportional to the number of *commits* because a single *commit* can contain many code changes or only a few code changes. The median of the line of code was 391, and its average was 1175. As we can see in Figure 7, the two students committed over 15,000 lines of code to their projects. These *commits* were not program code but JavaDoc documents that were automatically generated. The line of code of JavaDoc in team 8 was 13,527, and that in team 11 was 13,221. The median of the entire line of code that each team added was 2,339, and its average was 5,128.

Analysis of Student Survey

After the PBL classroom, we surveyed 53 students and obtained 51 responses using Microsoft Forms. Figure 9 shows the result of the survey. The students of 63% had no experience in the use of Git before the classroom (Q1). The students of 51% felt a sense of belonging to a team (Q2), and 49% answered that using GitHub increased the project's motivation (Q3). Although the students of 47% have mastered the essential operation of Git and GitHub in the classroom (Q6), 65% found the usage of Git difficult (Q4). The answers to Q5 (What was the most difficult task in Git?) are:

- ✓ Resolving a *merge conflict* (13 students)
- ✓ Complexity in Git operations (9 students)
- ✓ Git operations in Eclipse (2 students)
- ✓ I cannot understand what Git is (2 students)

Resolving a *merge conflict* was the most challenging task for the students. A *merge conflict* is an event that takes place when Git is unable to automatically resolve differences in code between two *commits* when two students edit the same lines. Some students could not resolve *merge conflicts* between members at all.

The students of 90% thought that the experience of team programming will help their future carrier (Q7). Moreover, the students of 51% preferred to use Git in other classes, such as programming and graduation study (Q8). On the other hand, the students of 61% felt the use of the history in GitHub in grades negatively. Only the students of 16% have used GitHub on their smartphones to review code outside the classroom.

Discussion

The correlation coefficient between the number of *commits* and team grade was -0.598. Moreover, the correlation coefficient between the line of code and team grade, excluding the line of code in JavaDoc documents, was -0.036. For example, team 11 has the highest grade in our PBL classroom; while the number of *commits* of team 11 was only 10, the line of code was 16,423 (3,202 LOC except for JavaDoc documents). The instructor

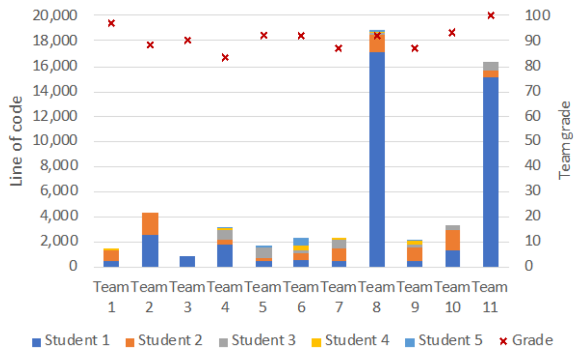

Figure 7. Line of code students added and team grade

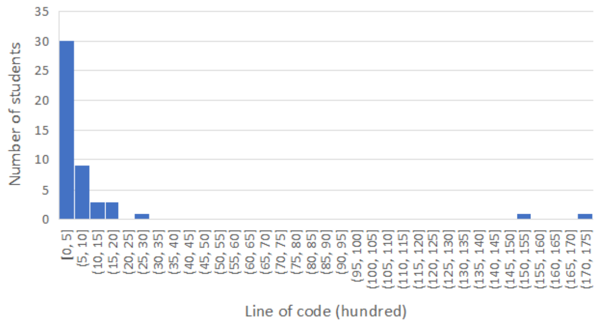

Figure 8. Histogram of line of code per student

found that the specific member of team 11 is familiar with Git and GitHub; he combined multiple *commits* into a single *commit*. Thus, we concluded that the number of *commits* is an unreliable metric for grading because a single commit can have many codes and vice versa.

In our experimental results, we could not confirm the correlation between the line of code and team grade. We did not evaluate code quality because it is very time-consuming. GitHub Classroom, on the other hand, provides an auto-grading function using GitHub *Actions* for the submitted code of the assignment. Such auto-grading tests perform input-and-output tests to verify whether the program's output is correct or not. In contrast, in the PBL classroom, the goal of each team is different from others; thus, the instructors cannot use such automation tools to grade the projects. One possible solution to measure the team performance is a peer review among students through demonstration and presentation in addition to the instructor's assessment. We have employed the rubric to measure each team's performance; the students can access the rubric.

On the student survey, we found that the most challenging task was resolving a *merge conflict*. Since our introductory hands-on seminar does not cover the use of the *branch* function, many students suffer from *conflicts* in the *main* branch. We thus recommend instructors to teach the *branch* function even in the introductory course. It will help students to use Git, especially in team programming. On the other hand, the students of 61% felt the use of the history in GitHub in grades negatively. As we presented, the students' behavior did not correlate with team grades in our PBL classroom (please note that the results do not include

Q1: Have you ever used Git and GitHub before the classroom?

Q2: Has team programming on GitHub increased your sense of belonging to a team?

Q3: Has team programming on GitHub increased your motivation for the project?

Q4: Did you find the usage of git difficult?

Q5: What was the most difficult task in the use of git?

Q6: Have you mastered the basic operations of Git and GitHub?

Q7: Do you think team programming will help you in your future career?

Q8: Would you like to use Git and GitHub in other classes such as programming and graduate research?

Q9: Do you agree that the instructor uses the history on GitHub such as the number of and the quality of code for grades?

Q10: Have you ever used GitHub on your smartphone to review the code outside the classroom?

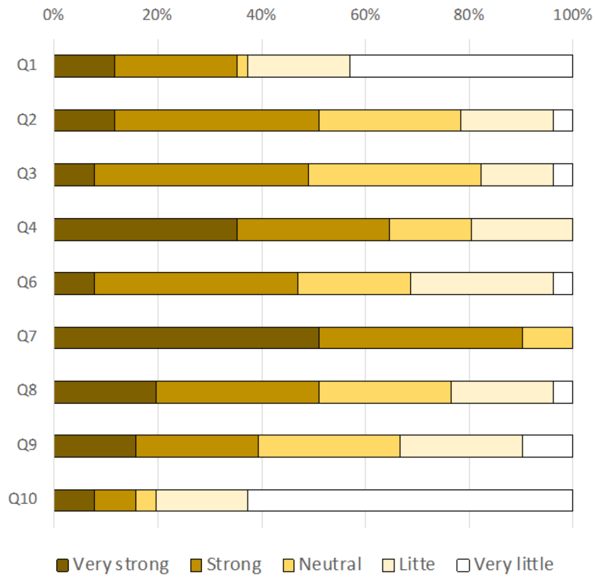

Figure 9. The results of student survey

analysis on the individual level). From a peer review perspective, students in the classroom can always see and assess other teams' work through GitHub. Furthermore, GitHub has a social network function called *Stars*, similar to Facebook's *Like* function. The students that are *starred* will be encouraged; such a social peer review system will increase the students' motivation in a GitHub-based collaboration environment in the classroom.

Conclusion

Blumenfeld et al. claimed that a good project has the potential to help children learn. They also claimed the importance of the final artifact they created in the project because it can be shared and critiqued (Blumenfeld et al., 1991). This paper presented a case study of using GitHub in the PBL classroom of cloud application development. The students shared their final artifact on GitHub; each student's contribution to the projects was recorded and analyzed. In the exit student survey, the students of 90% think that the experience of team programming will help their future carrier.

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What and How are Students Learning in an Engineering Ethics Class?
- An Attempt at Discourse Analysis and Video Review Using Multiple Recordings -

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Abstract

Since the mid-1990s, engineering ethics, which originated in the U.S., has been recognized as an essential element in engineering education. As a result, engineering ethics has been rapidly integrated into the curriculum of engineering faculties in Japan. In accordance with these processes, perceptions have changed from a teacher-based to student/learner-based learning process. In other words, there was a change from the "what is taught" to "what is learned."
Preceding studies on engineering ethics education have mainly focused on the educator's viewpoint. However, determining how students learn has mostly been based on the analysis of students' pre- and post-questionnaires, and not on the student learning process itself, or the actions of teachers.
Teaching is "a complex activity involving diverse values and factors" (Akita & Sakamoto, 2015, p. 228) and is "an interaction that students develop with others over the content of the subject matters" (Akita & Fujie, 2019, p. 3). In this sense, it is necessary to observe and describe how teachers and students act and discuss in class, and how teachers teach and students acquire knowledge, in addition to curriculum development using the pre- and post-questionnaires of students in educational research on engineering ethics. Therefore, this study examines discourse analysis and video review in a class on engineering ethics, focusing on the interaction between teachers and students and the learning process.
In our research, we conducted a trial class, recorded the group work on video, described the teacher's and student's discourse, behavior, and actions, and reviewed the class.
From the transcripts and video recordings, we analyzed and discussed that "the learning process of ethics for engineers," "how group work actually works," and "how teachers interact and work with the students," and then categorized them by the student learning process from these three viewpoints. We found that students did not only complete the assigned tasks, but they also constructed better arguments on their own initiative, dynamically adjusting and integrating their knowledge through discussion. We conclude that discourse analysis and video review are effective measures for confirming these learning processes.

Keywords: *engineering ethics, video review, discourse analysis, learning process, interaction between teachers and students*

Introduction

Since the mid-1990s, engineering ethics, which originated in the U.S., has been recognized as an essential element in engineering education. As a result, engineering ethics has been rapidly integrated into the curriculum of engineering faculties in Japan (Fujiki, 2011) (Sugihara et al., 2017).

To determine the best method of teaching engineering ethics in Japan, the research committee of the Japanese Society for Engineering Education (JSEE) conducted various research and analysis and developed educational methods such as learning /educational goals, teaching materials, and evaluation methods (Fudano, 2011) (Kobayashi et al., 2014). The research committee of JSEE established the Learning and Educational Objectives (JLEO, 2016) and Model Syllabus of engineering ethics education with reference to Bloom's taxonomy, and published them in 2016 (Table 1) (Kobayashi & Fudano, 2016).

Table 1 JSEE's Learning and Educational Objectives 2016 (JLEO, 2016)

Cognitive domain	Category 1 : Understanding the relationship between science and technology and society/environment
	Category 2 : Understanding the roles, obligations, and responsibilities of engineers
	Category 3 : Ethical decision-making and problem-solving skills
Effective domain	Category 4 : Attitude and value as an engineer to be shared

However, as we have indicated, research studies on engineering ethics education so far have mainly focused on the educator's viewpoint. There have been many studies and reports on "teaching content" and "teaching methods." However, studies on the student learning process were often based on an analysis of the scores of students' pre- and post- questionnaires, rather than teacher behavior in class or the student learning process itself (Takehara, 2021) (Takehara & Fujiki, 2021).

Teaching is "a complex activity involving diverse values and factors," (Akita & Sakamoto, 2015, p. 228) and is "an interaction that learners develop with others over the content of the subject matters" (Akita & Fujie, 2019, p. 3).

In this sense, it is necessary to observe and describe how teachers and students act and discuss in class, and how teachers teach and students acquire knowledge, in addition to curriculum development and student pre- and post-questionnaires in educational research on engineering ethics.

Therefore, we introduce a method of discourse analysis and video review in a class on engineering ethics, focusing on the interaction between teachers and students and the learning process.

In our research, we conducted a trial class, recorded the group work on video, described the teacher and student discourse, behavior, and actions, and reviewed the class. From the transcripts and video recordings, we analyzed and how students learn.

Methods and Analyses

Although our research activities were restricted by COVID-19, we conducted the educational practice research in 2020–2021.

The curriculum for the regular courses of National Institute of Technologies is generally consisted of 5-years learning process. In February 2021, we held a class on engineering ethics as a part of human environmental studies for 5th grade students, corresponds to the sophomore of undergraduates. In July 2021, we conducted similar classes entitled "Public" for the 3rd grade students equivalent to the 3rd year high school student.

As the recording method, the entire classroom and the group work of the students were filmed and recorded using a WEB camera and PC (Figure 1–2). In the group work, a few groups were randomly selected from all the participants and recorded, respectively.

The class progressed as follows: First, students studied the "Seven-step guide to ethical decision-making" (Davis, M. (1999) by watching the video learning material (Muroran IT, 2008). Next, they watched "Solar blind" (Kanazawa IT, 2009). Finally, the class was divided into groups and group work was conducted based on the "Seven-step guide to ethical decision-making."

For the analysis, the video recordings were transcribed. From the transcripts and video recordings, we analyzed and discussed that "the process of discussion = the learning process of ethics for engineers," "how group work actually works," and "how teachers interact and work with the students," and then categorized them by the student learning process.

Figure 1 Video recording of the entire classroom (the July 2021 class data)

Figure 2 Video recording of group work (the July 2021 class data)

Results and Discussion

The Process of Discussion

Table 2 shows how much time each group spent on the Seven-step guide to ethical decision-making in the July 2021 class data. Table 3 outlines the conclusions of each group in the July 2021 class data. As shown in Tables 2 and 3, it is obvious that each group proceeded with discussions based on different procedures, with different conclusions, processes, and durations.

In addition, we found that after opinions had been stated, there were conflicts and agreements, changes in opinions, divergence, convergence, and integration in the process of discussion in group work.

Moreover, we found that students did not only complete the assigned tasks, but they also constructed better arguments on their own initiative, dynamically adjusting and integrating their knowledge through discussion.

As the process of discussion varies, it is difficult to predict the course of a discussion.

Of course, the difference itself is one of the reasons for engineering ethics education because there is no predetermined correct answer to engineering ethics questions, and answers depend on the situation and context in which engineers are immersed. Therefore, not

only knowledge of engineering ethics, but also the ability to solve problems in cooperation with others are required.

That is why debates and discussion in engineering ethics education is recommended. In the JSEE's Learning and Educational Objectives, "ethical decision-making and problem-solving skills" are established as one of the educational goals (Table 1: Category 3 of JLEO 2016). And PBL or discussion using case studies are prepared in the model syllabus to enable acquisition of those abilities.

Therefore, teachers should recognize that it is important to develop problem-solving skills while collaborating with others by focusing on the group work process, rather than just evaluating the group work output, e.g., conclusions and submitted worksheets.

Table 2 Time each group spent on the Seven-step guide to ethical decision-making (the July 2021 class data)

		Group A	Group B	Group C	Group D
step0	Empathic understanding	3:56	1:39	3:46	1:38
step1	State the problem	3:44	3:15	3:25	1:35
step2	Check the facts	3:32	2:10	4:51	3:00
step3	Identify relevant factors	9:32	3:44	4:23	4:10
step4	Develop a list of options	4:57	8:51	8:41	6:32
step5	Test the options	16:29	9:05	16:27	15:57
step6	Make a choice	1:32	18:52	2:00	3:43
step7	Review	6:55	NR	9:31	10:57
	Total	50:37	47:36	53:04	47:32

Table 3 Conclusions (the July 2021 class data)

	Step7:Review step 0-6
Group A	Early detection of problems Communication with employees and colleagues
Group B	Communication with employees and colleagues
Group C	Share safety throughout the company
Group D	Establishment of a neutral third party Early discovery of problems

How Group Work Actually Works

The goal of this group work is to "complete the worksheet by introducing the Seven-step guide to ethical decision-making," so students work together to achieve it. How do students acquire "better" practices in these situations when "the answer is uncertain?" From the transcripts and video recordings, we found that the students discussed not only the contents of engineering ethics, but also how to proceed with the discussion.

For example, the moderator in each group discussed the definition of words, the meaning of the questions, how to proceed with group work, etc. while sharing opinions with other members.

Group work cannot be achieved simply by gathering people together. It is premised upon a mutual relationship of "accepting others," so that actions such as nodding and agreeing can work properly. In addition, actions such as nodding or agreeing can act as an "opportunity" and "connection" which are triggers for subsequent discussions, and this activates case study discussions.

Here we found that the group work in engineering ethics education is strongly linked to the "Attitude to accept a diversity of values" and "Attitude to share values" in the JSEE's Learning and Educational Objectives (Table 1: Category 4 of JLEO 2016).

Therefore, teachers should be aware of the importance of accepting the presence of others in group work and advising students to develop such attitudes. In addition, they should also recognize the importance of the role of the moderators who are elected from each group.

How Teachers Interact and Work with The Students

So, how do teachers interact and work with the students? Video review by the teacher provides an opportunity to observe class improvement. Teachers engaged in various behaviors; sometimes they spoke to all the students; sometimes they silently patrolled the classroom; and sometimes they interacted with specific groups during the class. However, not all such behaviors had successful outcomes.

For example, one teacher continued patrolling the room without stopping to mediate one group's discussions or to offer advice or a trigger to change the discussion when the discussion had stalled. There was also a scene where the teacher gave misplaced advice due to a misunderstanding of the situation. Furthermore, from the transcripts and video recordings, we found that students sometimes complained about the meaning of the words and the perplexing nature of the questions on the worksheets made by the teacher. Of course, there were cases where appropriate advice was given.

In this way, video review makes it possible to recognize outcomes of teacher behavior such as failures and successes. It also enables analysis of these factors. Teachers can determine how to improve the lesson preparation by, for example, revising and recreating the worksheet and explaining, advising, and presenting how to ask questions in class.

Conclusions

In this paper, we conducted a trial engineering ethics class, recorded group work and made transcripts. From the transcripts and video recordings, we analyzed and considered thet "the process of discussion = the learning process of ethics for engineers," "how group work actually works," and "how teachers interact and work with the students," and then categorized them by the students' learning process. As a result, we obtained the following three findings.

First, there is no predetermined correct answer to engineering ethics problems, and therefore each group proceeded with discussions based on different procedures, different conclusions, processes, and durations. Given the diversity of the discussion process, it is important for teachers to not only evaluate the results of group work, such as conclusions and submitted worksheets, but also to focus on the group work process to develop problem-solving skills while collaborating with others.

Second, we focused on the function of group work itself in our analysis. As a result, we confirmed students discussed the contents of engineering ethics, and “how to work in groups” at the same time. We found that during the discussion, they often showed their understanding by nodding, agreeing, and repeating others’ opinion, and such attitudes activate the discussion and also show their implicit acceptance of others. Therefore, teachers should be aware of the importance of accepting the presence of others in group work and advising students to develop such attitudes.

Third, we focused on the learning process, including the behavior of teachers, and analyzed how teachers interact and cooperate with students. From the transcripts and video recordings, we found that teachers are involved with students while engaging in various behavioral patterns such as providing guidance, questioning / utterance, patrolling, and giving advice in the classroom. However, not all of these actions are successful (of course, appropriate guidance may be given). This indicates the effectiveness of teachers reviewing their own video for class improvement. Teachers can improve their lessons appropriately by analyzing the factors of “success or failure of behavior in the lesson“ while recognizing “teacher involvement“ and “student reaction.“

Previous practical research on engineering ethics education focused on the educator's perspective. To analyze the student's learning process, the scores of the pre-class and post-class questionnaire surveys were frequently used, and the behavior of teachers in the class was not included in the analysis.

This study analyzed the actual behaviors and conversations of students and teachers through discourse analysis of group work and video review. As a result, several important perspectives and issues were revealed from the findings in this study. We showed that these perspectives and issues could lead to improvement of the class. Therefore, it is important to focus on the learning process in engineering ethics education.

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ENGINEERING EDUCATION FOR SUSTAINABLE DEVELOPMENT AS UNAI HUB FOR SDG9

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Abstract

Nagaoka University of Technology (NUT) was appointed as the global hub university of the United Nations Academic Impact (UNAI) for SDG9 (Industry, Innovation and Infrastructure) for two consecutive terms, as a model university for innovative efforts related to the SDGs (Sustainable Development Goals).

NUT was founded in 1976 to cultivate leading engineers with practical and creative abilities, and its motto is the spirit of VOS (Vitality, Originality, Services). NUT provides education based on "GIGAKU = Science of Technology" and produces engineers who have capable of creating innovation in the industrial fields. In recent years, NUT prepares education and research environment with global capabilities. Among these pedagogically environments, the promotion of College of Technology (KOSEN)-NUT Collaboration and Industry-Academia Collaboration have played a major role, and activities of the education and research have been consistent with Goal 9 of the SDGs.

In 2016, NUT quickly defined SDGs education as the objective of university and promotes public understanding for SDGs. In FY2016, the 1st STI-Gigaku, an international conference focusing on SDGs, was planned and implemented by students, and student participants clarified the number of SDGs to be targeted and presented research results that lead to the solutions for achieving the SDGs. In addition, NUT has been achieving results in research and development in science and technology, and the promotion of public understanding.

In 2017, NUT developed the "GIGAKU SDG Institute," as an education program that fosters leading engineers with practical and creative abilities and a desire to serve society in the future with an SDGs mind. This program has been recognized as the first UNESCO Chair Programme among engineering universities in Japan, namely "UNESCO Chair on Engineering Education for Sustainable Development". This program consists of three courses for high school and KOSEN graduates, working professionals, and foreign students. All of these courses are designed and run with an emphasis on SDGs which should be acquired by the next generation of engineers. NUT is creating a network that contributes to a sustainable society through engineering education.

Keywords: *GIGAKU, Engineering Education, SDGs, UNAI, UNESCO*

Introduction

Nagaoka University of Technology (hereinafter designated as NUT) was founded in 1976 to cultivate leading practical engineers who will create innovation. Its motto is the spirit of Vitality, Originality, and Services (VOS). Of the students who graduate from KOSEN (College of Technology), 80% transfer as third year students to programs to receive an integrated Undergraduate–Master's engineering education. Especially, NUT conducts engineering education based on "GIGAKU (Science of Technology)" and produces innovative human resources in the field of industry.

Through its unique engineering education, NUT fosters human resources with widely various abilities, including ability in the field, ability to pursue research, ability to innovate, ability to practice, ability to develop as a person of integrity, as well as ability for technical application through Academia–Industry collaboration. This education program has continued to receive high acclaim among industry. Most students who have completed this program found jobs with excellent companies and public organizations in Japan and overseas. They are advancing their careers actively around the world.

In 2017, NUT incorporated the concept of Sustainable Development Goals (SDGs) into its existing education

programs and established the "GIGAKU SDG Institute." This incorporation allows the new program to progress to a new engineering education program that contributes to common global goals for a better society. Furthermore, the GIGAKU SDG Institute has been producing many leading engineers of the next generation. As a consequence, in recognition of its past performance, NUT was appointed the United Nations Academic Impact (UNAI) SDG9 Hub University in the first term (2018 – end of May 2021.) Furthermore, NUT was re-appointed as an SDG9 hub university in the second term (2021 – end of May 2024), in which status it promotes education and research aimed at achieving all objectives related to Goal 9 (Industry, innovation and infrastructure) and promotes social contribution activities toward achieving the SDGs as the world's only SDG9 hub university.

This paper, in addition to recognizing the role that engineering education should carry out in achieving a sustainable society, introduces the characteristics and effects of the GIGAKU SDG Institute: an educational program developed by NUT.

GIGAKU Education

Since its foundation in 1976, NUT has continued implementation of education based on "GIGAKU" for students. The education philosophy based on "GIGAKU" has been succeeded by the engineering education program "GIGAKU SDG Institute" established in 2017, for which GIGAKU has remained as an important keyword.

As the basic concept of NUT's education and research, GIGAKU is defined as the "form of science, concerned with technology, which enables us to refine and develop technological systems and scientific methods further by grasping the diverse technical processes and subjects which are facts of modern life. Through broad understanding of management, safety, information, and life science rooted in the disciplines of physical science and engineering, GIGAKU creates practical technology with an eye toward future innovation." GIGAKU was advocated by Prof. Masamitsu KAWAKAMI, the first president of NUT, when the university was opened. Plainly speaking, GIGAKU means the Science of Technology.

GIGAKU serves to identify technical problems in the practice of production processes that produce goods and systems in the ordinary workplace, conduct scientific analysis and verification of these problems, and apply the results to solving various problems. That is to say, GIGAKU is a fusion of academic theory and practice by the feedback action of academic theory and practice. Therefore, GIGAKU education is intended to train leading engineers with practical and creative abilities that can contribute to the prosperity of humankind, and to cultivate human resources capable of global technology expansion.

GIGAKU SDG Institute

The UNESCO Chairs education program promotes international inter-university cooperation and networking to enhance institutional capacities through knowledge sharing and collaborative work. This program, which was adopted in the 23rd session of the General Assembly held at UNESCO Headquarters, involves over 850 institutions in 117 countries. UNESCO Chairs promotes international collaboration and cooperation, with the aim of playing a role as think-tanks and bridge-builders between academia, civil society, local communities, and policy-makers. In Japan, 10 institutions of education programs have permission from UNESCO to establish as a UNESCO Chair.

In 2017, NUT's unique pioneering education program of "GIGAKU Education" was reconstructed as the "GIGAKU SDG Institute" with the SDG philosophy as the aim of education and research. This engineering education program develops leading engineers with an SDG mindset, with the practical and creative ability to contribute to a future sustainable society, and imbued with the desire to serve. This "GIGAKU SDG Institute" program has been certified as UNESCO Chairs Programme as "UNESCO Chair on Engineering Education for Sustainable Development." It is the first engineering university in Japan to be certified under the UNESCO Chair Program.

As shown in Figure 1, the SDG-related educational course at the GIGAKU SDG Institute program comprises the "SDG Engineering Course (Joint Bachelor–Master program)," "SDG Professional Course (Master–Doctoral program for international graduate course for continuing professional development)," and "GIGAKU Innovation Program (Department of Science of Technology Innovation)." Graduates of high schools, KOSEN, and universities, as well as members of society, both Japanese and international students, are able to select courses according to their interests at their own convenience. Three courses are based on the concept of particularly addressing the 17 goals of the SDGs that the next generation of engineers should acquire and which are designed for all students to foster awareness of contributing to achieving the SDGs.

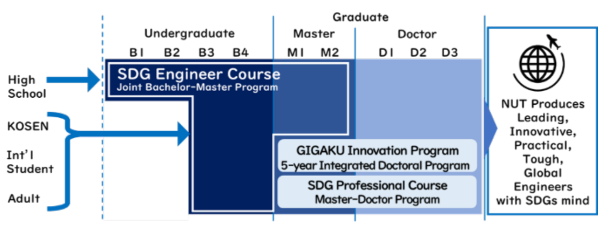

Figure 1 GIGAKU SDG Institute

Summaries of the courses are presented below.

SDG Engineering Course:
This integrated Undergraduate–Master's course is the core of the university's SDG initiatives (with the greatest number of enrolled students). During the fourth year of undergraduate study, students will be able to experience directly, and have awareness of, SDG-related challenges faced by the organization through Jitsumu-kunren (long-term internship). In 2022, the "Innovation Frontier Course" was newly established for undergraduate students, aiming at the cultivation of STEAM personnel strongly required by society, and practical engineers who can play an active role on a global scale by contributing to Society 5.0, which is aimed at achieving the SDGs.

SDG Professional Course:
This special course for graduate working adult international students provides advanced and practical engineering education and SDG education to students from economically developing countries. Scholarships were funded by donations from "SDGs Private Placement Bonds" issued by a city bank. Students from Sri Lanka, Bangladesh, and other countries have received scholarships. Students in this course have become leaders in resolving SDG issues in their respective home countries.

GIGAKU Innovation Program:
This integrated Master's–Doctoral course of the graduate school is an educational program that integrates different fields and different cultures based on a global integrated campus. This course fosters personnel who have the ability to create innovation and active on the global stage, and who can become outstanding leaders of Japanese and global industries. Many course students are engaged in activities to raise awareness about the SDGs, have developed SDG educational games and awarded in business competitions, etc. Students are having remarkable success. In 2019, the "WISE program / Doctoral Program for World-leading Innovative & Smart Education" by the Ministry of Education, Culture, Sports, Science and Technology – Japan was launched. Outstanding students from this GIGAKU Innovation Program were selected as WISE program students. The WISE program cultivates "Knowledge Professionals" who have knowledge of sociology, business administration, and who are sufficiently qualified to be leaders in international affairs in addition to engineering.

In addition, GIGAKU SDG Institute offers learning opportunities of the following five types for students.

SDG Class:
Students learn how to find and resolve issues related to SDGs in the undergraduate general studies and graduate common subjects. They also understand the common issues and demands of international society, such as SDGs, and see things objectively and logically, in addition to performing analyses by integrating knowledge from several areas.

SDG Research project:
Through joint research with local companies and other organizations to understand the current circumstances and issues (industry, resources, and society) in a region, students can support the revitalization of local economies and industries.

SDG Conference:
As a place for student–society connection, students and companies from Japan and overseas present their research results at international conferences. NUT has held an international conference "STI-Gigaku" organized by students every year since FY2016 as an avenue to promote education and research for achieving SDGs and to exchange information.

Long-team internship (Jitsumu-kunren)/ Work based learning (WBL):
Students complete long-term Jitsumu-kunren (internship) and research internships conducted in Japan and overseas to recognize insufficiency of practical knowledge and skills. Also, students can experience feedback between academic theory and practice. Students will also have opportunities to work on SDG-related issues facing the companies or communities to which they are dispatched.

SDG Business planning:
Through business plans, venture plans, and policy planning, students learn how the results of their research are applicable and how they are used in the real world to achieve the SDGs. Students can obtain an MBA through cooperation with other universities. To realize their own ideas and plans, they can participate in business planning forums and competitions, or start their own businesses while in school by taking advantage of support systems for establishing venture companies, etc.

Student-led International Conference "STI-Gigaku"

In addition to the description above related to learning opportunities offered by the GIGAKU SDG Institute, this paragraph introduces the "STI-Gigaku" international conference, which is particularly noteworthy. The "STI-Gigaku (International Conference on "Science of Technology Innovation")" is a forum for research presentations particularly addressing SDGs. It is organized and managed by students. The conference is characterized by student expression in their own words and student expression of the results of students' research and their contribution to achievement of any SDG-related goal.

STI-Gigaku has been held annually since FY2016. The first to fourth sessions were held onsite and were moderated by students from the Department of Science

of Technology innovation / GIGAKU Innovation Program. During the poster session, presentations were made on activities leading to the resolution of SDGs and results of joint research conducted by KOSEN and NUT. Presenters gave a 90 second oral presentation in English at the beginning of the poster presentation. This poster session was managed in a way that only students can implement. All their presentations were clarified for participants. Since the fourth conference, private companies have also participated in the conference, in addition to universities and KOSEN in Japan and overseas. STI-Gigaku is providing a forum for exchanges that transcend fields and positions.

The fifth conference, in response to the COVID-19 pandemic, was held for the first time in a hybrid format combining online and on-site participation. Taking advantage of the online participation, five universities of the UNAI SDGs Global Hub University appointed by the UN in 2018, including NUT, gave keynote speeches, with active discussions taking place between the audience and speakers. The "Best Moderator Award" was presented to one person who asked an outstanding question, and the "Best Research Presentation Award" and "Crown Award" from the company were presented to students who gave outstanding research presentations oriented toward SDG solutions.

Although the sixth STI-Gigaku was held only in an online format (Figure 2 and 3), the number of participants was similar to those of earlier years, with approximately 300 participants from 14 countries, including universities, KOSEN, companies, and research institutes from Japan and overseas. Meaningful opportunities for exchange of opinions between NUT students and participants were provided, such as holding a "round-table talk" as an alternative to the laboratory tour at the site which was canceled. STI-Gigaku hosted more than 1,600 participants from NUT, universities in Japan and overseas, KOSEN nationwide, companies, and local governments. It is not only a venue for international discussions and information exchange, but also a venue for promoting SDG-awareness raising activities and initiatives to achieve SDGs.

Figure 2 Group photo of student committee members at the closing ceremony

Figure 3 Plenary Session

Student Organization "Student SDGs Promoter"

Because NUT has been aware of SDGs from an early stage, it has been particularly active in "building resilient infrastructure, promoting inclusive and sustainable industrialization, and fostering innovation" based on practical engineer education. Through the development of educational materials and holding lectures aimed at dissemination and raising awareness of the SDGs, NUT has created opportunities to familiarize people with the SDGs, raised awareness of the SDGs in the local community, and spread awareness of the SDGs as a "personal matter" to the entire community. The "Student SDGs Promoter" plays a part in these activities.

The "Student SDGs Promoter" was established in 2020 as a student organization with the aim of spreading awareness of SDGs inside and outside the campus through the free ideas of students together with faculty and staff members. International and Japanese students of all ages, from undergraduates to working adults, have shown interest in this initiative. In fact, 38 students have been appointed as Student SDGs Promoters to date. Students plan and collaboratively manage their own events.

In FY2020, online seminars were held three times. Several overseas experts participated in these seminars as guest speakers. In 2021, as part of activities to promote the SDGs among local residents, the SDGs Promoters exhibit PR booths at city events and large supermarket chains. They provide opportunities to learn about SDGs while having fun using SDG games. In addition, during the event called "Beach Cleanup × Learning," SDGs Promoters introduced NUT efforts to achieve the SDGs through scientific experiments, thereby communicating the perspective of engineering to children who are expected to form the next generation of leaders. In 2022, the SDGs Promoters presented good practices and experienced shared outcomes learned from Jitsumu-kunren and the SDG initiatives being implemented by internship sponsors.

Every year, an SDGs Round-table Talk for students is held as a place to learn the basic and applied SDGs. The SDGs promoters give a presentation called “Research × SDGs” to share the relevance of the SDGs to their own research. In the Round-table Talk, the group work and brainstorming using the Jamboard, as shown in Figure 4, were conducted. The solutions as future engineers were discussed, such as considering food loss and waste from the perspective of life cycle assessment (LCA).

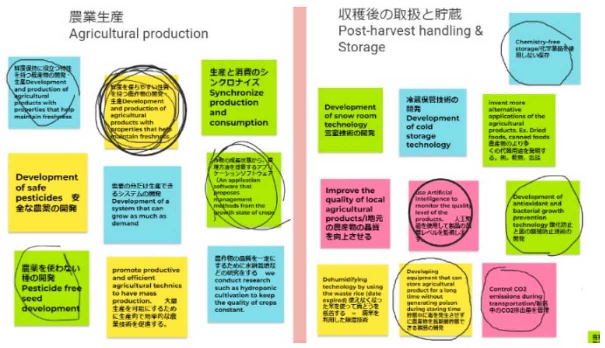

Figure 4 An example of group work with Jamboard

As described above, activities of the Student SDGs Promoters also provide an opportunity to demonstrate their practical abilities of building up education programs of the GIGAKU SDG Institute.

Prospects for the future

In 2019, NUT established the “GUGAKU SDG Network”: a global network of universities and higher education institutions. It was established as a global organization to develop the “GIGAKU SDG Institute” which has been certified as a UNESCO Chair Programme, and to form engineering education programs with the pillars of SDG achievement and practical engineering education.

As shown in Figure 5, the GIGAKU SDG Network includes 10 organizations from six countries (India, Japan, Mexico, Mongolia, Spain, and Vietnam) and Thai enterprises (observers) representing the industrial field. Each organization examines specific areas of expertise and conducts engineering research to identify new values and issues that contribute to achieving the SDGs through the network. The network facilitates student mobility, interaction, and faculty collaboration through attendance of conferences and workshops organized by network members. In addition to providing learning environments such as problem-oriented learning and group discussions related to the SDGs, regular events will be held to promote new joint research and exchanges.

As an outlook for the future, NUT intends to build an engineering education program that further evolves the GIGAKU SDG Institute by enhancing and using the SDG Network. In addition to providing students with higher quality engineering education, NUT hopes to contribute to SDG achievement, i.e., security and safety in the region, in Japan, and around the world.

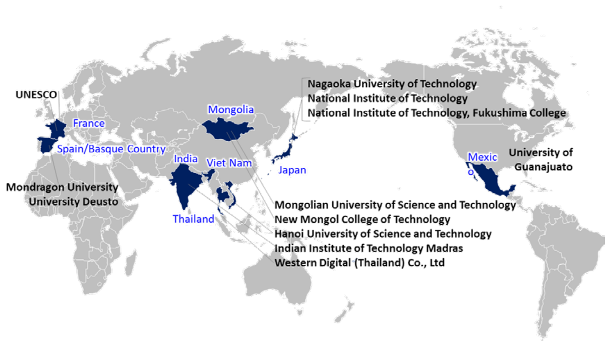

Figure 5 GIGAKU SDG Network

Conclusions

In 2022, NUT launched the “Innovation Frontier Course” as a new educational program for SDG Engineering Course undergraduate students with the aim of producing human resources able to create and lead new industrial fields by undertaking unexplored or integrated fields while emphasizing conventional engineering. This new course will foster global engineers who can actively apply IT technology to contribute to Society 5.0: human resources able to lead industrial advancement and revitalization, able to create new industries in cooperation with local governments and local communities, and able to become the core of local revitalization and respond to new areas into which diverse fields are integrated. Furthermore, through engineering education based on the GIGAKU SDG Institute, NUT will continue to produce human resources with an interest in SDGs, able to see them as business opportunities, and able to contribute their free ideas, originality, and ingenuity to the realization of a better society.

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EMERGING TECHNOLOGIES IMPACTING AUTHENTIC ASSESSMENT PRACTICES FOR DIGITAL EDUCATION IN HIGHER EDUCATION

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Abstract

Assessment is a powerful lever that affects learning. To better inform educators on authentic assessment practices within digital education in the higher education landscape, this paper takes us through a meta-analysis of existing literature between 2011 to 2021. The study evaluates the following research question: How are emerging technologies, as identified in Educause Horizon Reports for 2011 to 2021, shaping authentic assessment practices in digital education for the higher education landscape. Through an evaluation of the question, the study hopes to (i) understand emerging technologies and trends, and their influence on authentic assessment practices, and (ii) provide an analysis as to how technologies and trends, and authentic assessment practices may evolve in the coming years. This study affirms the importance of immersive learning technologies, and ubiquitous and adaptive learning technologies as key growth research interest areas impacting authentic assessments in the coming years. Results from this study found that application of immersive learning technologies on authentic assessments is presently highly prioritized as a research area. However, this may likely be overtaken by applications of adaptive learning technologies in the near future. In addition, the application of ubiquitous learning technologies on authentic assessments offers much promise, having grown extensively in research intensity since 2011, overtaking learning objects. The study can help researchers understand past, present and future metatrends of emerging technologies shaping authentic assessment practices, and identify promising potential areas for research and/or investment focus.

Keywords: *Authentic Assessment, Assessment Design and Practice, Emerging Technology and Trend, Digital Education, Higher Education*

Introduction

Assessment is perceived with importance by many scholars as "*the most powerful lever teachers have to influence the way students respond to a course and behave as learners*" (Gibbs, 1999). Assessment practices in higher education (HE) have been under growing attention (Postareff et al. 2012), with increasing demand for the application of more innovative and effective practices to measure students' achievements, building upon higher levels of accountability and expectations for learning (Asghar, 2012).

While digital education is not new, it is especially integral in the HE educational landscape in the fourth industrial revolution. In a Commonwealth of Learning concept paper Curriculum for Digital Education Leadership by Brown et al. (2016), digital education is defined broadly as the "*process of teaching and learning involved in fostering capabilities that are needed for an individual to live, learning and work in a digital society*." In particular, the key tenets of digital education include:

1. Empowering learners with the ability to learn, live and work in a digitally-mediated society.
2. Imbuing learners with the technical means to utilize and reproduce digital resources, and the capacity and agency as change agents to critique and develop innovative digital resources and practices in the existing or future social and market structures.
3. Imbuing learners with the critical cognizance of digital culture and practices, and how these can impact and modify relationships, and social and market practices.

There is a predilection towards connecting assessment activities to authentic and meaningful digital technology and innovation practices similar to the many manifestations of practicing technologists and innovators with diverse tools and processes. Authenticity in learning and assessments practices is the most likely way to produce "*greater understanding and provide opportunities for students to identify, simulate and relate to the tacit knowledge of technologists [and innovators]*" (Fox-Turnbull, 2015). To formalize the definition of authentic assessments in this paper, we adopt the definition by National Research Council (1996), which defines authentic assessment as "*assessment exercises [that] require students to apply knowledge and reasoning to situations similar to those they will encounter in the world outside the classroom, as well as to situations that approximate how [practicing professionals] do their work*."

To better inform educators on authentic assessment practices within digital education in the higher education landscape, this paper takes us through a meta-analysis of existing literature between 2011 to 2021. The study evaluates the following research question:

How are emerging technologies shaping authentic assessment practices within digital education for higher education for the forecast period between 2011 and 2023?

Through an evaluation of the question, the study hopes to (i) understand emerging technologies and trends, and their influence on authentic assessment practices, and (ii) provide an analysis as to how authentic assessment practices may evolve in the coming years. This can help researchers decide where to focus research efforts in the coming years.

Reviewing Technology Trends Influencing Education

There are various bibliographic and reference sources where expert predictions of relevant future applications of technology in education are made. These include journals relating to education technology (such as the British Journal of Educational Technology, and Educational Technology Research and Development), conferences on education technology (such as the Future of Education Technology® Conference, and IEEE EDUCON Engineering Conference), and periodic or ad hoc market trend publications (such as those from Global Market Insights Inc.).

In this study, following the well cited research effort by Martin et al. (2011) published in Computers & Education, we utilize the Horizon Report (HR) as a point of reference for an annual technology prediction impacting education, and look to apply this on assessment practices. HR explores and predicts technology developments impacting education from a broad perspective, inclusive of teaching, learning and assessments. Since 2004, HR has released free and publicly accessible annual predictions of key global emergent technologies on education; no other resource has issued annual trend publications for a longer period of time. Published by EDUCAUSE, HR has been a widely read and highly regarded educational technology resource for higher education practitioners. A blunt (but useful) indicator of the volume of references, commentaries or discussions related to HR – with albeit a publication track record of 17 years, approximately 234,000 results can be found from a google search of HR (excluding contents from EDUCAUSE home site) (Google search entry: *+"horizon report" -site:educause.edu*). Predictions of technology use can come with its challenges, as extricating present experience to providing visions of the future is inherently 'anticipatory'. However, it is a necessary endeavor to anticipate the future.

This work studies HR reports from year 2011 to 2021, which cover technology metatrends between 2011 to 2023. The annual HR methodology involves surveying expert panelists to yield trend perspectives – in a short term (year of report), mid term (two to three years from year of report), and long term (four to five years from year of report). It is an ever fruitful endeavor to continually improve survey methodologies – an undertaking EDUCAUSE undertook since its 2020 report. This resulted in a change in methodology. For each annual publication from 2020, the trend prediction time horizons were removed, in favor of discussions on broad trending technologies and practices impacting education by the expert panelists.

To corroborate results from the metatrend hypotheses, bibliometric analysis is applied. To evaluate metatrend hypotheses, methods including technology investment and sales, technology uptake reports, and patent analyses were considered. However, these methods yielded unreliable insights (Martin et al., 2011). The former two methods involve quantitative data which were difficult to validate. The latter method of patent analyses relates more to commercial and industry, rather than education-related research, which limited its usefulness. Bibliometric is a commonly applied method to analyze trends and emerging technology, via indicators including publications, citation and occurrences of words, among others (Daim et al., 2006). As at the time of this work, there are around 5,000 articles relating to education research involving bibliometric analysis at Google Scholar (Google Scholar search entry: *intitle:(education AND bibliometric)*). Recent education-related works that used bibliometric analysis include Huang et al. (2020), and Marín-Marín et al. (2019). Bibliometric analysis requires sufficient and verifiable data for temporal comparison. Google Scholar is a good tool for bibliometric analysis, as it provides a comprehensive, quantifiable and verifiable search across a wide range of academic repositories, including JStor, Springer, Wiley, Mendeley and IEEE, among others.

Methodology

This study follows the methodology applied by Martin et al. (2011). The steps are as follows:

1. Record trends of technologies and/or practices affecting education from HR between 2011 to 2021. Create visual representation of the trends, by grouping technologies according to their similarities and creating detailed views for each group. Trends of technologies and/or practices that have no relation to assessments are excluded. Analyze the key metatrends observed and map against assessment practices in published literature within the period under study.
2. Perform bibliometric analysis as an objective evaluation of emerging technologies shaping assessment practices. This step includes measuring the impact of predicted technologies in assessment practices, by searching and computing the number of papers published between 2011 to 2021 for each relevant technology group in bibliographic databases. Using Google Scholar as a bibliometric analysis tool, the following sub-steps were taken:

2.1 Google Scholar Search

2.1.1 *Technology group*: Selection of keywords were made for similar groups of technology, *e.g.* "mixed reality" and "augmented reality".

2.1.2 *Assessment*: The keyword "assessment" is too broad and it includes e.g. assessment of research results, teaching practices etc. Hence keywords "authentic assessment" were used to narrow the scope of search.

2.1.3 *Education approach*: The term "digital education" was used to scope the type of education under study.

2.1.4 *Education level*: "Higher education" was used to scope the education level under study.

2.1.5 *Publication title*: Keyword search was narrowed to the title.

2.1.6 *Year of publication*: A total of 11 searches were conducted for each set of keywords, from 2011 to 2021.

An example of a Google Scholar search entry is as follows: *intitle:+("mixed reality" OR "augmented reality") +("authentic assessment") +("digital education") +("higher education").*

2.2 Evaluation

2.2.1 *Weighting factor:* As the number of authentic assessment-related education papers varies each year, a weighting factor is applied to the results for each technology group to allow for comparison across different years. Weighting factor (WF_i), as shown in Eq. (1), is computed by dividing the mean number of papers published across the period under study, against the number of publications at year i.

$$WF_i = \frac{\bar{p}}{p_i} = \frac{\frac{1}{N}\sum_{i=2011}^{2021} p_i}{p_i} \quad (1)$$

where $\bar{p}$ represents the mean number of publications from 2011 to 2021, p_i represents the number of publications at year i, i represents the period {2011, 2012… 2021}, and N represents the total number of years.

With the application of the weighting factor, the years with lower publications of authentic assessment-related education papers will not be unduly penalized.

2.2.2 *Evaluation of metatrend against bibliometric results*: This step is the objective assessment of HR predictions against bibliometric results.

Results: *Metatrends and Technology Clustering*

Results of step 1 of the methodology is compiled in Fig. 1. In Fig. 1, the rows represent the year of the horizon report, and the columns represent the prediction period of the technologies. Note that prior to 2020, the HR survey methodology predicts the technology trend for the year of report, for two-to-three years ahead (mid-term), and four-to-five years ahead (long term). From 2020 and beyond, HR only discusses emerging technology trends based on the year of the report; as such the forward period predictions of two years and beyond do not apply.

Each technology cluster is grouped by color based on similarity: (i) orange cluster represents technology trends related to ubiquitous learning technologies, (ii) yellow represents technology trends related to adaptive learning technologies (AI), (iii) blue represents technology trends related to immersive learning technologies, and (iv) grey represents technology trends related to learning objects.

Results: *Bibliometric Statistics*

A detailed bibliometric analysis research is performed to assess if the defined technology group had predicted impact on authentic assessments in digital education in the higher education landscape. Table 1 shows the number of papers available in Google Scholar in authentic assessments for each of the analyzed years. The weighting factor is computed based on Eq. (1).

Table 1: Number of papers published in Google Scholar in authentic assessments between 2011 to 2021, along with their weighting factor.

Year, *i*	Number of papers available, p_i	Weighting factor, WF_i
2011	3130	1.566366541
2012	3890	1.260341201
2013	3970	1.234943897
2014	4300	1.140169133
2015	4570	1.072806843
2016	4780	1.025675162
2017	5150	0.951985878
2018	5350	0.916397621
2019	6020	0.814406524
2020	6140	0.798489784
2021	6630	0.73947621

Figure 2 is the graphical representation of the number of papers available in Google Scholar for each technology group in each of the analyzed years, weighted based on Eq. (1).

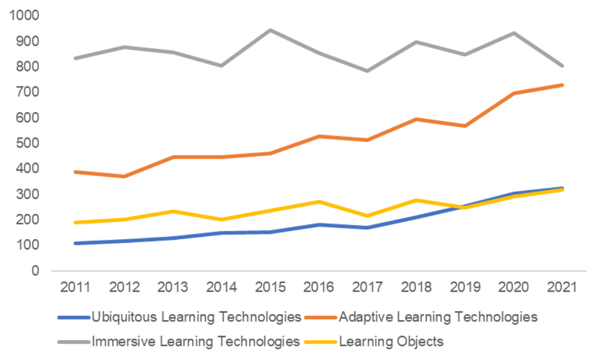

Figure 2: Number of papers published in Google Scholar in each technology group between 2011 to 2021, adjusted with weighting factor in Eq. (1).

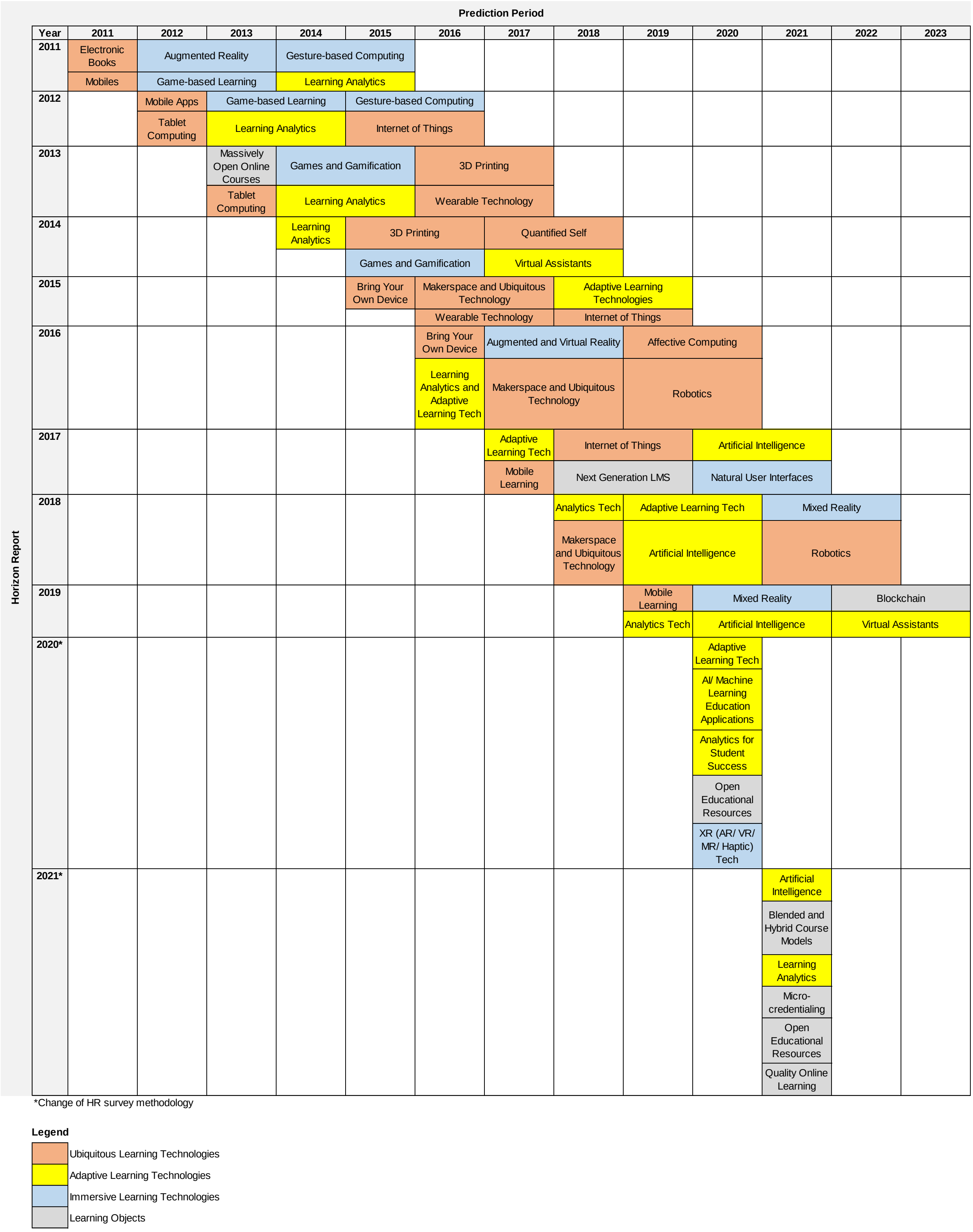

Figure 1: Emerging technologies impacting education based on Horizon Reports from 2011 to 2021.

Discussion

Immersive learning technologies are educational technologies that creates, for the purposes of learning and assessment, an immersive environment for the interaction between a representation of self in some form, such as an avatar, with digital artifacts, agents, and contexts (Gaspar et al, 2020). Such technologies can be represented in the form of an immersive simulator, such as a flight, medical and firefighting simulator, or a game-based immersive educational virtual world of augmented reality or mixed reality, such as Lord of the Ring Online.

Immersive learning technologies generated the highest publication interest as at 2021, after weighing for the effect of overall publication numbers. Its publication numbers were consistently around 800 to just under 950 per annum between 2011 to 2021. It was consistently mentioned in nine of the 11 years under study in HR. The consistency in research interest is evident in the continued HR predictions tied to immersive environment-related education and assessments, including game-based environments, and mixed reality environments (e.g. virtual reality, augmented reality). While the initial cost for equipment and development of the immersive assessments may be high, this is arguably offset by the relatively cheap adaptation of the content for different authentic scenarios, the lower cost of maintenance, ease of portability and the relatively modest space requirement (Engelbrecht, Lindeman & Hoermann, 2019). This technology area has high ecological validity for authentic assessments, but is still plagued by issues such as relative immaturity of technology, uncertain skill transfer, and lack of specialization and testing of systems.

Adaptive instruction refers to the “real-time modification of the instructional curriculum, learning environment, or training regimen to suit different student characteristics” (Shute, Lajoie & Gluck, 2000). Analytics and AI can be considered critical aspects supporting adaptive learning technologies.

Adaptive learning technologies generated the second highest publication interest as at 2021, after weighing for the effect of overall publication numbers. It is noteworthy that while adaptive learning technologies represented less than half of the research interest in immersive learning technologies in 2011, the gap between the two technology groups has shrunk to less than 10%. In fact, the weighted number of publications of adaptive learning technologies almost tripled in the 11 years under study. There are well documented ethical debates regarding the use of AI in assessments, and in particular, grading. However, among other benefits, the possibilities of the use of analytics and AI in assessments as part of an authentic learning intelligent tool to measure personalized cognitive skills, and provide analysis and feedback of learner performance, progress and potentials are highly useful (Chassignol et al., 2018). Adaptive learning technologies trended across all of 2011 to 2021 in HR. If allowed to continue in its current trend, it is expected that assessments driven by analytics and AI will take a larger role in the coming years.

Ubiquitous (or pervasive) computing, a term introduced by Weiser (1991), is the notion of providing resources and information beyond research laboratories to the real world at any desired time or location, through the use of computational resources, to augment both people and environment. The application of ubiquitous technology has the potential to provide authentic and situated digital assessment experiences. For instance, mobile technologies, internet of things (IoT)s, robotics and wearable technologies can help in the hypersituating of assessments.

Ubiquitous learning technologies generated the third highest publication interest as at 2021, after weighing for the effect of overall publication numbers. The weighted number of publications started from a low base of 107 in 2011, and ended the period under study by tripling to 323, overtaking learning objects. Ubiquitous learning technologies trended across all of 2011 to 2019 in HR. While there is resistance to the adoption of assessments tied to ubiquitous learning technologies, e.g. possibility of cheating owing to poor monitoring mechanisms, change in socialization dimensions from group to individual, and cost of implementation (Sophonhiranrak, 2021), most threats are surmountable and ubiquitous learning technologies offers much opportunities in enhancing the authenticity of digital education. The tripling of weighted publication numbers during the period under study is a testament to the growing interest in assessments tied to ubiquitous learning technologies. This technology group is an area that has much potential to explore in the coming years.

According to Wayne Hodgins, a learning object is defined as “a collection of content, practice and assessment items to achieve a learning objective” during technology-supported education (Gerard, 1967). These learning object tools are the independent and reusable digital entities that support the delivery of education during technology-supported learning. Examples of such learning object entities include multimedia instructional content, and instructional software and software tools, etc. Tools, which do not fall under the above immersive, adaptive, and ubiquitous categories, are broadly classified as learning objects.

When weighted for the effect of overall publication numbers, it is observed that assessments tied to learning objects generated the lowest publication interest as at 2021. Correspondingly, learning objects were mentioned the least in HR – only in five of the 11 years under study. The higher mentions in HR from 2019 onwards, is in line with the growing research since 2019. These coincided with effects of Covid-19 on broad-based education, including assessments. It is observed that learning objects only started receiving more mentions in recent years in HR, owing partly to pandemic-related need for assessments tied to more quality online courses (including micro-credential short courses), blended and hybrid course models, and open educational resources.

Conclusion

The findings suggest that the predictions by HR can be used as a basis for metatrend analysis of emerging technologies shaping authentic assessment practices within digital education for the higher education landscape. The quantitative bibliometric analysis generally corroborates well with the qualitative HR predictions, with one exception – the higher publication numbers in learning objects vis-à-vis ubiquitous learning technologies prior to 2019, despite having lower HR mentions. Prior to 2011, trends such as open educational resources (e.g. MIT OpenCourseWare) and quality online learning were already of research importance. The higher recent mentions post-2019 in HR were largely driven by the Covid-19 pandemic.

HR predictions are qualitative in nature. The quantitative bibliometric statistics, despite being a lagging indicator (time required to research and publish), provide a clear evolution of trend which can be used for future trend predictions for focus research and/or investment areas. For instance, adaptive learning technologies, albeit being the second most highly published area in 2021, is highly likely to surpass immersive learning technologies as the number one research area in the near future. Further, having tripled in publications over the past 11 years and having overtaken learning object in research intensity, ubiquitous learning technologies showed promising potential as a focus research and/or investment area.

Technology is growing at a rapid pace at multiple directions. Future research can look to provide a more detailed, mapped and streamlined guidance on how each technology area (or sub-areas) can influence assessment practices, with illustrations of such assessment practices for educational or research practitioners. It will also be useful to consider research similar to the Gartner Hype Cycle for emerging technologies and trend that may significantly affect assessment practices, to inform and prepare educators and researchers of potential changes coming in the years ahead.

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VIDEOREVIEW TOOL AND WORKFLOW TO DETECT UNAUTHORIZED COLLABORATION IN BYOD OPEN E-TESTS

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Abstract

In summative tests and examinations, close invigilation of students within a physical venue is often regarded as the best method to deter cheating. However, in Bring-Your-Own-Device (BYOD) open e-Tests of individual competence, where the only manner in which students may cheat is by unauthorized collaboration, mere physical monitoring is often insufficient to deter cheating. This is because device-screens are often too far away from invigilators and when there are only a few invigilators to monitor many students, collaboration can be hidden, for instance by rapid window-switching.

For BYOD open e-Tests at Ngee Ann Polytechnic (NP), students are required to use a screen recorder (Kaltura) to capture and share all their on-device actions for post-test review. However, reviewing post-test videos is tedious and prone to human error. Hence, the development of a tool the authors call "VideoReview" to automatically scan such videos for unauthorized collaboration.

VideoReview uses Microsoft's productivity tools to collect and validate, from students, links to their videos. VideoReview then integrates various open-source artificial intelligence tools into a locally-installed application, which mimics the human eye to batch-scan video-streams for unauthorized collaboration.

VideoReview was trialed in both eProctored and physically-invigilated open e-Tests over 3 semesters in different disciplines with up to 100 students per e-Test. Qualitative feedback from lecturers and students involved in the trials suggested that the tool was efficient and effective at detecting suspicious on-screen conduct, thereby providing a level of deterrence against cheating in BYOD open e-Tests that was previously unachievable. However, it could be improved for reliability.

In conclusion, VideoReview is a viable solution to fully review all students' recordings of on-screen actions during BYOD open e-Tests. However there is scope to further enhance its reliability through redesign. The authors propose details of the redesign and also ways to broaden the tool's feature-set beyond detecting unauthorized conduct in BYOD open e-Tests.

Keywords: *robotic process automation, invigilation, proctoring, cheating, collaboration, e-Tests, screen recording, screen-capture, automated video review*

Introduction

Individual summative assessment tasks allow students to demonstrate their progress in learning. Often these individual summative assessments, for example tests or examinations, are conducted under strict invigilation conditions in a physical setting, where close monitoring makes it relatively difficult for students to cheat, including by collaboration with others.

During the COVID-19 pandemic, and as was done in many other countries, Singapore imposed mandatory social-distancing "circuit breaker" lockdowns to curb the spread of infections. These resulted in campus closures and the implementation of "home-based" learning. Together with other educational institutions in Singapore, Ngee Ann Polytechnic (NP) pivoted all tests to be delivered online as e-Tests, to be taken by students in their own homes.

The pivot to home-based e-Tests, and the disruption caused by the pandemic in general, increased the receptiveness of NP lecturers and students towards changes to assessment design and delivery. Examples of such changes included more "open-book" e-Tests that focused on the demonstration of higher-order thinking skills. Open-book e-Tests allow students to freely refer to resources during the e-Test, but without outsourcing the construction of their e-Test answers to others.

Students in open-book e-Tests can cheat by collaboration in the same physical space, or share resources over networks using the test-taking device or other devices.

How can the risk of collaboration or answer-outsourcing in an open-book e-Test be addressed?

Open-book e-Tests and eProctoring

Close physical invigilation is often thought of as a "gold standard" to deter cheating of any type. However, the 2nd author discovered following a physically-invigilated open-book e-Test in his own module that cheating by collaboration over a network can occur even in a closely physically-invigilated setting. This discovery drove him to develop the tool described in this paper. Without the pandemic, the tool would have been experimented with in physically-invigilated e-Tests. The pandemic made a quick pivot to remote invigilation or eProctoring necessary. Therefore, while the pandemic provided the authors with a particularly receptive audience to develop and experiment with a process around the 2nd author's tool to reduce the risk of cheating by collaboration when the student's test-taking device cannot – by design – be technically locked-down and blocked from accessing networked resources, it also meant that such development and experimentation went hand-in-hand with another change which was NP's pivot to eProctoring.

Research shows that eProctoring can be rigorous enough to be equivalent to physical invigilation, for example as established in a rigorous comparative study of more than 14,000 candidates who took high-stakes tests over a year, pre-Covid, in live remote online and onsite physical invigilation settings (Weiner & Hurtz, 2017). Further, advances in e-Test technology including "automated algorithms" for pattern-recognition could be used to support the "pre-identification" of cheating, especially where lecturers are "unlikely to" explicitly code for "cheating propensity" in a high-marking volume, time-pressured situation (Butler-Henderson & Crawford, 2020, citing Dawson & Sutherland-Smith, 2017).

Deterring cheating in eProctored Open-book e-Tests at NP

NP trialled processes and tools during the pandemic to deter both forms of collaboration in open-book e-Tests – online and off (that is, in the physical test-taking space). To deter physical collaboration, including the use of unauthorised devices, invigilators required students to use only one computer to take their e-Tests and to allow invigilators to continuously monitor their physical test-taking environments via video live-streams from their own smartphones.

But how is online collaboration using the test-taking computer prevented? The student's smartphone is used primarily to monitor the student and his or her physical environment and is placed at such a distance and angle that the test-taking computer is usually too far away for invigilators to be able to clearly see the details of students' onscreen actions during the e-Test. Invigilators can and did require students to record their onscreen actions for later review. However, such post-test reviews of the entire cohort of students' videos were time-intensive, and it was only practical to review students' videos at random or where cheating was suspected. The review process was also error-prone since invigilators could overlook unauthorized collaboration if they scanned through videos too quickly. Hence, there was a need to improve the review process for greater effectiveness as well as efficiency. This led to the further development of VideoReview – the 2nd author's automated video scanning tool - to improve both the quantity and quality of post-test video reviews.

VideoReview

VideoReview is a video-scanning system that not only scans students' videos but is able to track, collect and check the videos submitted by students post-test. The first version of VideoReview was developed in Python in December 2020. It has since been trialed and iteratively improved in open-book e-Tests over 3 semesters, 2020-2021, in different disciplines across NP with between 12 and 101 students per e-Test. NP Schools that trialed VideoReview included the Schools of Business & Accountancy, Engineering, Health Sciences and Life Sciences & Chemical Technology.

How does VideoReview work?

During an open-book e-Test, students activate their **Kaltura Capture** application to record their onscreen actions. Students then upload their videos into NP's video-based learning portal **iVid2** and submit their video web-links to invigilators for review via **MS Forms**. The uploaded links are matched to students' identities in a **SharePoint portal** to allow invigilators to track video submissions.

Invigilators then trigger the **VideoReview application** installed in their laptops to automatically access and review students' videos in sequence. This application mimics the human invigilator's eye to scan streaming students' videos for unauthorized collaboration.

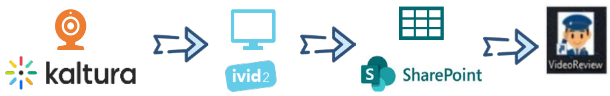


Figure 1: a visual summary of the VideoReview system.

During the scanning process, VideoReview scans each video in sequence without manual intervention, integrating the following open-source tools to detect unauthorized collaboration via students' laptops and web-cameras:

- Tesseract Optical Character-Recognition (OCR) for key-word detection.
- OpenCV for image template matching.
- TensorFlow Artificial Neural Network (ANN) for facial identification.

VideoReview also employs Selenium to batch-process videos to increase the speed of the video scanning.

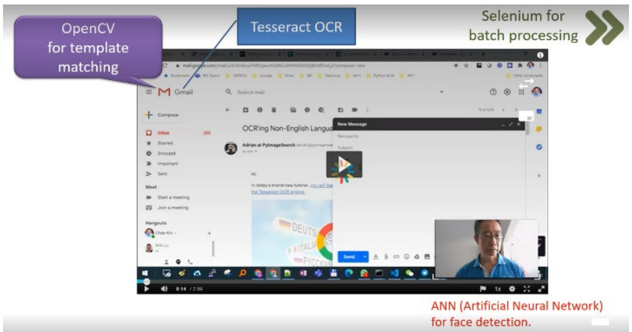


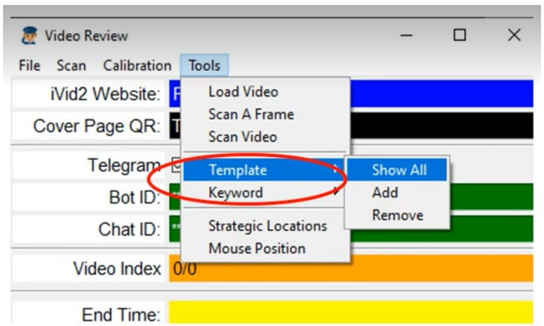
Figure 2: The 2nd author shows what VideoReview "sees" in the streaming iVid2 recording and describes the role of each open-source tool within the application.

As the VideoReview application scans streaming videos at the same speed as human invigilators, it saves time not by moving faster but by automating the task so that invigilators do not need to perform it themselves. When behaviors in the video suggest unauthorized collaboration is detected, VideoReview logs the event with particulars such as at which timepoint in the video it was detected and what kind of conduct it was. Invigilators inspect the VideoReview reports to determine which videos and when in each video to conduct manual reviews, and then upon whom to conduct further investigation.

Report:	.\Reports\[redacted].xlsx		
No. of video scanned:			
No. of video flagged:			
Absent:	[redacted] (Students' personal data hidden)		
No Link:			
Bad Link:			https://ivid2.np.edu.sg/media/[redacted]
Bad Link:			https://ivid2.np.edu.sg/media/[redacted]
Bad Link:			https://ivid2.np.edu.sg/media/[redacted]
Bad Link:			https://ivid2.np.edu.sg/media/[redacted]
Bad Link:			https://ivid2.np.edu.sg/edit/t/[redacted]
Name	Alerts	Time Stamp	Video Link
[redacted]	{'No WebCam'}	0:01	https://ivid2.np.edu.sg/media/[redacted]
	{'dropbox2_i'}	0:13	https://ivid2.np.edu.sg/media/[redacted]

Figure 3: screen-grab from a VideoReview report.

Examiners can select the onscreen actions considered unauthorized and for which the tool scans, using the tool interface. Such actions include using prohibited applications, as identified by clicking on prohibited application icons or typing their names.



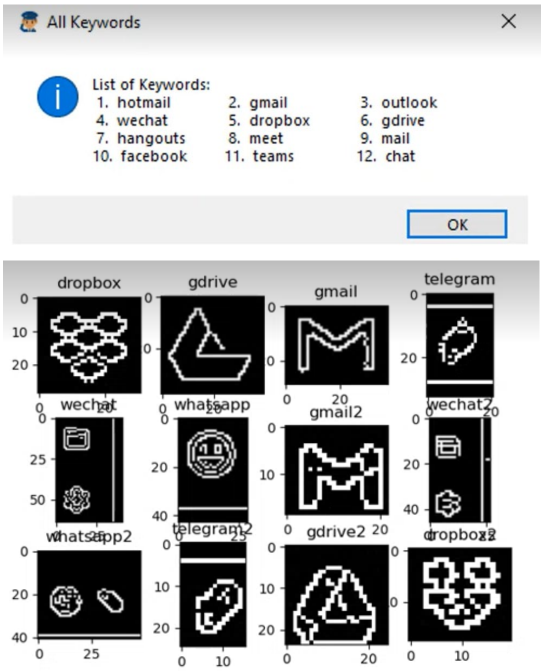


Figure 4: VideoReview interface enabling examiners to decide which icon templates and key words to scan for.

Findings

Feedback was collected from invigilators on VideoReview's effectiveness and efficiency in their post-test reviews of students' open-book e-Test performances.

Invigilators were positive about VideoReview as they saw how VideoReview can potentially increase efficiency in reviewing students' videos. Invigilators who were also examiners could focus on other more productive tasks such as providing feedback on students' learning, and less time on reviewing videos for cheating.

Examples of invigilator feedback include:

"It helped very much! I would still be struggling to review the different videos if it is not for this report. I think the segments are fine. In fact, I think the different checkpoints allow us to ascertain that the students are not engaging in any activities that they should not. I would definitely like to continue to use this for e-proctoring for this module in its subsequent run if it is possible."

"*Overall, the automated scanning tool was helpful in removing the need for invigilators to look through each video manually (e.g. was effective in pinpointing periods when students moved out of their camera zone, camera not on, etc).*"

"*Quite happy to have this software because it really saves a lot of my time and I can focus on more productive work.*"

Anecdotal feedback from students also showed that this process has created an awareness among students about an automated tool that can detect cheating behaviour and this acts as a deterrent to such behaviour. For example, some NP School of Engineering students

informed invigilators after a mock test with VideoReview: *"We cheat, and you catch us!"*

Data from 101 students' video submissions at NP's School of Business & Accountancy showed that VideoReview had a success rate of 95%, meaning that the videos were scanned by VideoReview successfully. The remaining videos could not be viewed due to technical errors such as VideoReview failing on the student's computer.

Issues with the implementation of VideoReview

The authors also received feedback to improve the current system. Technical issues that remain unresolved include the VideoReview application's unexplained failure to work on one laptop where it successfully worked on another with identical hardware and operating system specifications.

In addition, VideoReview's proper functioning currently requires students to perform certain actions such as changing the privacy settings on their videos before sharing. These actions are tedious and error-prone, and cost invigilators valuable time and effort to educate students, thereby reducing the efficiency of the system.

For VideoReview to be more widely adopted, all technical issues would need to be resolved and more efficient yet effective processes would need to be developed to educate both staff and students on the proper installation and usage of the system.

Analysis and next steps

VideoReview is an effective and efficient video scanning tool that will continue to remain relevant even with the return of physically-invigilated e-Tests. This is because cheating via the test-delivery device is a risk in all e-Tests whether physically invigilated or not. VideoReview is *not* a necessary aid *merely* in eProctoring. The original intention of the development was to detect cheating via the test-delivery device in an open-book e-Test which was physically invigilated. Readers are reminded that the absence of evidence of cheating does not mean that it did not take place, but merely that it was not discovered.

Feedback from users and the authors' own observations suggest that - instead of further incremental changes - VideoReview should be completely redesigned to further enhance its efficiency, effectiveness and reliability. The redesigned VideoReview should include:

(i) A cloud-first tool that scans students' videos as files, uploaded into the same cloud. This avoids having to address Internet connectivity issues as videos currently stream from iVid2 to be auto-scanned by VideoReview on local laptops. It also removes reliance on individual laptops which tend not to be as reliable as, and require more institutional effort to maintain than, cloud services.

(ii) An integrated screen-capturing process to minimize the number of clicks necessary to capture, upload and share videos for scanning.

(iii) The ability to scan students' videos as files, frame by frame. This may scan faster and more accurately than a human eye can track changes on a streaming video, the resolution of which may be adversely affected by network conditions.

(iv) A broader feature-set to detect other kinds of unauthorized conduct besides unauthorized collaboration in Bring-Your-Own-Device (BYOD) open-book e-Tests. For example, VideoReview can be developed to detect the use of pre-typed code in programming tests, if such code is not allowed. Pre-typed code can temporarily be hidden from invigilators' view – but students must eventually make the code visible to themselves so that they can copy-type or copy-paste the code. VideoReview's continuous monitoring will detect and deter such behaviour, as long as it is defined for VideoReview to flag.

(v) Extended functionality to enable the assessment of performance tasks, such as actions students take during tests of competence in the use of software. The benefit for assessors might be faster, more reliable assessment of such actions, leading to more specific or targeted feedback to students. In this respect, a redeveloped VideoReview could apply to onscreen actions what sports coaches have for years applied to sports performances (O'Donoghue, 2006), for example in gymnastics (Boyer et al., 2009) and perhaps with fewer technical challenges since there is no need – unlike in sports - to analyse rapid live motion (Barris & Button, 2008).

Conclusions

This paper presents an example of how one lecturer quickly prototyped and, with the support of his institution, rapidly enhanced a package of established open-source and general-purpose commercial tools to help invigilators manage the very real and specific risk of unauthorized collaboration through the test-taking device in BYOD open-book e-Tests where students must demonstrate individual competence.

VideoReview is a viable solution to fully review all students' recordings of their on-screen actions during such e-Tests and therefore provides a level of deterrence against cheating in such e-Tests that was previously unachievable.

However there is scope to further enhance VideoReview's reliability through redesign. The authors have proposed some details of the redesign and also ways to broaden the tool's feature-set and applications beyond detecting unauthorized conduct in BYOD open e-Tests.

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The authors also gratefully acknowledge our NP colleagues who courageously trialled, provided feedback and shared on VideoReview. They shared not just with the rest of NP thereby helping to expand the reach and variety of our trials, but also with the wider Polytechnics and Institute of Technical Education (POLITE) community, thereby planting the seeds for potential further developments by the sector in this area.

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PRACTICE OF POETRY IN TECHNICAL EDUCATION FOR THE RESTORATION OF HUMANITY IN THE MODERN TECHNOLOGY SYSTEM

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Abstract

In the times of science and technology, we act on the principle of usefulness, always and everywhere. In this paper, I will point out that the problem in such times is that the perspective of things is biased, and I will clarify that poetry is required to have an opportunity to escape from such a crisis situation. Based on such philosophical considerations and interpretations, this article argues that the practice of art −especially poetry− is recommended in technical education at technical colleges, and provides examples of that practice. According to Heidegger's observations in his lecture "The Question Concerning Technology", in the system of modern technology we are exclusively forced to procure things as useful. In this system, things are always revealed merely as "useful things". Accordingly, in the system of modern technology, we no longer have any other possibility of revealing things, and we would then lose the possibility of recognizing our own essential ability to reveal things as they are. In this regard Heidegger pointed out the danger of modern technology, and it is precisely here that he nevertheless indicated a possibility of "rescue" through art, especially poetry. According to Heidegger's explanation of Hölderlin's poetry, in poetry, things are revealed by the essential word as they are. In my interpretation, the haiku-poet Matsuo Basho also understood this essence of poetry and wrote haiku poems in this way himself. In this sense, especially in the times of modern technology, poetry can contribute to the rehabilitation of the original possibilities to reveal. Therefore, we should recognize in poetry a possibility of "rescuing" in the times of modern technology. Such basic philosophical considerations are very important for modern society. At our college, I give a lecture on the problems of society, which is biased toward science and technology, and at the end of my class, students look for poems that reveal things as they are, or practice writing such poems themselves. Through the practice of such poetry, students will have an opportunity to regain the experience of revealing things as they are.

Keywords: *modern technology*, *useful*, *reveal*, *Heidegger*, *poetry*, *haiku*

Introduction

"The violets that bloom in the spring fields just need to bloom like violets." － Japanese Mathematician Kiyoshi Oka tried to solve the difficult problems of mathematics, just as violets bloomed as violets, regardless of the public question to him "what would you do with mathematics?" As Oka (2008) says, the violets that bloom in the spring fields need only bloom as violets, and whether they contribute to the beauty of the spring fields has nothing to do with the violets themselves. However, as if they asked whether violet flowers are useful for the beauty of spring fields, people in modern society are pursuing only the usefulness of things. As German Philosophers Adorno (1997) and Horkheimer also point out in the *Dialectic of Enlightenment* (1947), "usefulness" is pursued exclusively from the standpoint of enlightenment －therefore in the times of science and technology. In this way, nature must be perceived as "useful". For example, a superb water source will become "a fine water sampling area", and a land with beautiful landscape will become "a popular resort area". People in modern society lose the attitude of accepting things as they are, as if they were not satisfied with the violets just blooming as violets and tried to see the violets as a color to the spring fields.

As is well known, German Philosopher Martin Heidegger found the essence of modern technology in the system that drives humans to see things as "useful". According to Heidegger (2000), because of the essence of modern technology, human beings only reveal things as "useful" and lose the possibility of experiencing their essence of "revealing things as they are". Heidegger saw this situation as the danger of modern technology. In these discussions, Heidegger mentioned the potential for human beings to be saved from the danger of modern technology. According to Heidegger, art － especially poetry－can be "savior" in the midst of the danger of modern technology. Poetry should show us the truth of what we miss in the age of science and technology.

Based on this philosophical basis, at a technical college I give a lesson in which students themselves interpret works of poetry or create their own works. This lesson is an attempt to encourage improvement in technical education with the aim of restoring the original humanity in a situation where science and technology are overly praised and values are biased. In this article, I would like to explain the rationale for such a lesson and clarify the significance of this lesson.

Materials and/or Methods and/or Pedagogy

At first, I will explain the rationale for my class. It is also what is explained to the students in my class.

According to Heidegger's argument in his lecture "The Question Concerning Technology" (1953), in the system of modern technology, things are constantly procured as "useful". For example, in the case of hydroelectric power plants, as Heidegger (2000) says, a river "the Rhine" also appears as "useful". Moreover, in this case, human beings themselves have already been provoked to procure things as "useful". Certainly, as Heidegger says, modern people who are incorporated into the system of modern technology are eager to use the things they encounter to help their work. For example, for those who work at a beverage maker, the fine fresh water that they encounter while hiking is not just "fine water", but water that can be used as a material for new products, and for the employees of a land development company, the beautiful place they meet while traveling is not just "beautiful nature", but a place that can be a resort area that can be expected to attract customers. Driving human beings to make things "useful" is essential for modern technology. In this way, in the system of modern technology, human beings pursue only "useful things" and make it the standard of all actions to seek only those useful things. (Therefore, in technical colleges, students who prioritize immediate interests will not listen to philosophy lectures, and school authorities will abolish philosophy courses!) It can be said that such a situation is certainly remarkable in the modern technological civilized society that is trying to pursue efficiency thoroughly. Although human beings originally have the possibility of revealing things as they are, in the system of modern technology, human beings lose their original possibility of "revealing" by immersing themselves solely in revealing things as "useful". This, in other words, means that human beings no longer experience their essential possibility. Thus human beings are at risk under the domination of fundamental trends in modern technology.

However, Heidegger (2000) says here, using Hölderlin's verse, "Where there is danger, there will also be a savior." Heidegger seems to try to find one of possibilities of such "savior" in art. In the past, technology was not the only name for "techne", and "techne" was also "bringing 'what is true' to 'what is beautiful'", that is, the "poiesis of beautiful arts". And it was "Poesie" (poetry) that finally got the name "poiesis". Art is to reveal "what is true" as "what is beautiful", and it once again evokes the original possibility of "revealing" to human beings who are at the mercy of the system of modern technology. Here, according to Heidegger's argument in "The Source of Works of Art" (1935/36), works of art separate us from our customary. Therefore, through works of art, we can see things as they are, in a different way than before. As Heidegger (2003) says, if the truth of "what is" occurs inherently in a work of art, then through the work of art we must be able to see things exclusively as they are. Among such arts, Heidegger recognizes the fundamental meaning of "poiesis" especially in poetry.

So how does poetry reveal things as they are? According to Heidegger's understanding in his lecture "Hölderlin and the Essence of Poetry" (1936), the words first have the mission of exposing something as such, and thanks to such words, we humans can be in the midst of various things and can get involved with them. And the poet, according to Heidegger (2012), names things so that they are revealed as they are. Through the poet's naming in "essential word", things are first nominated for what they are.

The poet's abilities and the essence of poetry found by Heidegger are not simply limited to ancient Greek poetry or Hölderlin's poetry. According to my interpretation, also in Japanese poetry haiku, as Heidegger found, it is acknowledged that the poet's naming in "essential word" reveals things as such things. It seems that Japanese haiku-poet Matsuo Basho (1644-1694) had already clearly grasped the essence of poetry in his haiku theory and practiced it in his own haiku. Basho's doctrine, "Learn about pine from the pine itself, learn about bamboo from the bamboo itself" (Hattori, 1969) appeal to go away from "private intention", that is, subjectivity, and to be in line with "things" themselves. In this way, a haiku-poet reveals "things" as they are by directly relying on the "things" and expressing them in his own new words.

We can recognize one of the concrete practices of such poetry in Basho's work, for example, as follows:

the stillness_
the voice of a cicada
seeping into the crags
(translated by L. P. Lovee)

As is well known, this is one of the best Works in Basho's *Oku no Hosomichi* (1702), and was written at Risshakuji Temple in Yamagata. It is believed that Basho climbed up to the hall Shakado on the mountain near the evening. There he couldn't hear anything but the voice of a cicada. And, including even the sound of the cicada, the stillness of the whole mountain was perceived more and more conspicuously. This "stillness" can never be measured and understood scientifically. It is because the more accurate acoustic measurement equipment is used to measure the sound on the spot, the more the cicada's bark will be sensed and it will not be able to say that it is still. It can be said that in this work the stillness of the place is exactly expressed by Basho's original expression, "the voice of a cicada / seeping into the crags".

In other words, the expression "the voice of a cicada / seeping into the crags" is the original expression that was made possible for the first time by the poet Basho, and this expression shows the aspect of nature's exquisite stillness as such. This means that, in line with Heidegger's argument, the poet's naming in "essential word" reveals things as such.

As Japanese critic Kenkichi Yamamoto (2000) says, the poetry of haiku is an "intuitive grasp of the truth" through the experience of "things", which also aims at "an accurate recognition of all things in the universe." We can think poetry will make us see the truth of things that we have missed in the age of science and technology, where the way we perceive things is biased. When we are in a situation where we expose things exclusively as "useful" and encounter things only from that perspective in the system of modern technology, poetry must reveal and show us the truth of the things we encounter through experiencing "things" first hand.

However, since the situation in which Basho wrote haiku in the Genroku era is very different from the situation in modern times, we must naturally reconsider the significance and possibility of haiku in modern times. Nevertheless, it can be said that the poetry of haiku is still an attempt to grasp the truth of "things".

On the top
of the skyscraper
autumn has arrived. (translated by M. Sasaki)

This is the work of Japanese modern haiku-poet Kai Hasegawa. At the end of the summer, on the rooftop of a skyscraper towering over New York, he felt "autumn is coming" a little earlier. On a busy summer day on the ground, he sensed the arrival of "autumn" at the top of the "skyscraper", which is a collection of the best of modern technology. In this work, the contrasting words "the top of the skyscraper" and "autumn" give it a kind of loneliness. It is a loneliness that the skyscraper, which is a symbol of prosperity by modern technology, is also expected to turn into a ruin as time goes by. It can be said that it is also the loneliness of the scene that symbolizes the end brought about by the fundamental trends of modern technology. In this work, the truth of the arrival of autumn ─not only the arrival of autumn as a season, but also the arrival of the decline that will soon come to the prosperity of technology─ is accurately captured and simply expressed based on the direct experience at "the top of the skyscraper". We can say that this work reveals the phenomenon of the arrival of autumn in such a double sense as such by the naming in "essential word" of "autumn" at "the top of the skyscraper".

In this way, poetry must reveal and show us what we encounter as it is. In my class, which I call "Critique of Technological Society", at the technical college, I give an overview of Heidegger's philosophy, explain the discussions in his lecture "The Question Concerning Technology", and impose appreciation and practice of poetry on students based on the above-mentioned philosophical grounds. With the aim of reviving the original human ability to reveal things as they are, students are asked to look for poems that reveal things as they are, and to write poems that reveal something as it is. Students must present the work they find or create and explain what it reveals and how. In such tasks, it is important to look at the thing itself, rather than asking if it is useful. Seeing things themselves is now being lost in a technological society that pursues only the usefulness of things. Therefore, we must regain the attitude of seeing things themselves, against the fundamental trend of pursuing only the usefulness of things. This means to restore the original humanity, and it should lead to respect for human diversity, which has become a hot topic these days, and also to work on the protection of the natural environment, including measures against climate change.

Results and Discussion

According to the philosophical considerations so far, through poetry, that is, through writing poems by oneself or reading works of poetry, we experience that things are revealed as they are. In order to experience it, in my class students tried to look for poems that reveal things as they are, or to write poems themselves. Certainly some students searched for poems easily on the Internet, but some students worked on rereading works of poetry they had learned in school lessons. Other students who originally liked literature reread the poems of their favorite poets. Such efforts seem to have been quite fresh for students studying engineering at the technical college. Also, students who originally liked literature seemed to be pleased to appreciate poetry in their daily lives, which were biased toward engineering studies.

Here, I would like to show the works evaluated by the students in my class.

The summer
lost one sailor
in the sea. (translated by M. Sasaki)

A student picked up this work by Japanese haiku-poet Hakusen Watanabe. This is a wartime work, which describes an incident in which a sailor went missing in the sea during training one summer day. By describing the disappearance of a sailor in the sea as "lost", this work captures the situation where a human sailor was not treated as a human in the wartime regime or in the navy, but as if he were a part or tool for the war. In other words, this work reveals soldiers in the wartime as they were. The student accurately explained this situation.

Smoothly
made a sound with bamboo
snow at night. (translated by M. Sasaki)

Another student found this work by Japanese haiku-poet Shiki Masaoka. As you can see immediately, this work is about snowing on bamboo at a winter night. Even if it is snowing on a quiet, dark winter night, we won't notice it is snowing outside the house. However, when the snowflakes falling from the sky hit the bamboo leaves and make a "smooth" noise, we notice that it is snowing.

This work reveals a unique way in which "snow at night" is not visually captured, but is known for the "smooth" sound of bamboo. In other words, this work reveals "snow at night" as it is. The student found a kind of "discovery" in this work.

In addition, here is a tanka-poem, one of the poems that the students themselves wrote.

To winter trees
which know old wooden playsets
that no longer exist
is not familiar
artificial material.
(by Yuko Okamura, translated by M. Sasaki)

When the student for the first time after many years, went to the park where she used to play when she was young, the wooden playsets that were once installed were removed, and metal or plastic playsets were installed instead. In the old park, wooden playsets seemed to be familiar to the surrounding trees, but the newly installed artificial material playsets were not familiar to the surrounding trees, which made her feel uncomfortable. This work reveals the nature of artificial materials, such as artificial materials that do not fit into the nature of the park. Certainly, it can be said that this work reveals the playsets made of artificial materials as they are. This student captured and expressed the playsets made of artificial materials as it were.

In my class, the students were freed from their regular engineering studies and tried to read works of poetry. It seems that they were able to get away from their rigid thinking styles and values by experiencing discourses and perspectives in areas other than engineering. Now, at technical colleges, even Japanese language classes are spent on training how to write documents for job applications, and it seems that they provide no longer any opportunity to read literary works. None of the students picked up the poems they read recently. On the other hand, quite a few students reread the works they had encountered in elementary or junior high schools. From the perspective of overall human development, the curriculum of technical education should also guarantee opportunities to come into contact with art and literature.

Conclusions

If we humans can regain the original exposure of things within the system of modern technology, one of those possibilities seems to be found in the creation of poetry, as discussed in this article. Through poetry, we experience that a thing is exposed or revealed as it is. In the system of modern technology that is biased towards exposing things exclusively as "useful", the experience of such poetry must lead us in the direction of breaking away from such bias and restoring the original potential of "revealing".

The program of technical education should actively incorporate opportunities to become familiar with art − one of which is to work on poetry− in order to break away from the bias of technical education which prioritizes only science and technology. Interestingly, "technology" and "art" were born from the same root "techne". We should keep this in mind.

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Measuring Differences in Student Activity between Face-to-Face and Distance Learning Classes Using Biometric Measurements

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Abstract

Due to the COVID-19, distance lectures are increasingly replacing conventional face-to-face lectures. However, because of the change in student activity between face-to-face lectures and distance lectures, lecture methods that are effective in face-to-face lectures are not necessarily effective in distance lectures as well. If the differences in student activities between face-to-face and distance lectures are clarified, they can be used to select and choose lecture methods. However, it is difficult to objectively evaluate student activities through surveys such as questionnaires because the evaluation is based on student senses. In this study, we attempted to evaluate the differences in student activities between face-to-face lectures and distance lectures by measuring biometric information during the class with biometric devices worn by the students and measuring their activities in the class. The measurement devices included an oculomotor potentiometer, a voice recorder, a cerebral blood flow measurement device, and an electroencephalograph, and the experiment was conducted with the participants wearing the devices while attending the class. Two types of lectures were prepared: one was a lecture that incorporated group learning into the classroom lecture, and the other was a lecture that focused on group learning. The lectures were delivered in a hybrid lecture format, where lectures were delivered remotely from the classroom, where they were conducted face-to-face. Group A was divided into two groups: Group B was divided into two groups: Group A attended lectures that incorporated group learning into classroom lectures at first, and then attended lectures that focused on group learning in a distance learning format; Group B attended lectures that incorporated group learning into classroom lectures at first, and then attended lectures that focused on group learning in a distance learning format. The students then attended classes that focused on group learning in a face-to-face lecture format. The data measured by the biometric device was then analyzed. As a result, it became clear that there was a difference in biometric data even when the same lecture was given remotely and in person, and we succeeded in visualizing the student activities.

Keywords: *Distance Learning, Student Activity, Biometric Measurements*

Introduction

Due to the COVID-19, ICT-based distance learning has been increasing. Various types of classes exist, but it is unclear whether the methods that have been effective in traditional face-to-face classes are also effective in distance lectures. One method to examine the effectiveness of such methods is through subjective evaluation based on questionnaires, but it is difficult to accurately compare the effectiveness of face-to-face classes with that of distance classes because it is not objective information. One of the methods of evaluating classes with objective indicators in lectures is to measure the biometric information of students and objectively analyse the results based on numerical values.

The purpose of this study is to examine a method of objectively evaluating the activity status of participants by measuring their biometric information in the same class, both face-to-face and distance learning. The biological information includes eye potentials, head acceleration, cerebral blood flow, electroencephalogram (EEG), skin potentials, and speech volume, and is analysed using quantitative measurement data.

Materials and/or Methods and/or Pedagogy

As a concrete method for visualizing the effects of proactive learning and ICT-based education, we will conduct experiments to construct an index for determining the degree of concentration by creating and verifying a prototype that "students are concentrating when such data appear" from data on blinking, cerebral blood flow, skin potentials, and speech volume when they are concentrating on a task. Experiments will be conducted to verify the prototypes and to construct an index for determining concentration.

We will collect a large amount of data, compare the collected data with the prototype, and verify the prototype by analysing the types of activities and the use of ICT to see in what situations during class the students' concentration level increases. We will also verify the validity of the prototype based on the collected data through questionnaires, etc., and aim to complete the judgment index.

In the experiment, students were divided into two groups, Group A and Group B. Each group took two different classes. The two classes are a mathematics class and a class on information security, both of which include group work. Group A students attend a mathematics class in a face-to-face format, and then attend a class on information security via a distance method. Group B students attend a mathematics class in a remote format, and then attend a class on information security in a face-to-face format. Students wear eyeglass-type devices, portable brain activity measurement devices, portable EEG measurement devices, skin potential measurement devices, and voice recorders to collect biometric information during the class.

Measurement instruments used in the experiment are following.

JINS MEME, manufactured by JINS, Inc., which can measure eye potentials and head movements, was used as the eyeglass-type device. This device can measure eye blink, eye movement, and three-dimensional head acceleration.

The HOT-2000 from NeU was used as a portable brain activity measurement device. This device can measure changes in cerebral blood flow related to the participant's brain activity.

EMOTIV EPOC+ manufactured by EMOTIV was used as a portable EEG measurement device. This device can measure the electrical changes that occur due to the activity of the participant's cranial nerve cells.

The BITalino Board Kit manufactured by BITalino was used as the skin potential measurement device. This device can measure the skin potential of the skin of the wearer.

Results and Discussion

A mathematics lecture using ICT technology and a group activity-based lecture about infromation securty were conducted in remote and face-to-face formats with the same content, and the biometric data of the participants were measured. The lectures in this experiment was conducted on September 23 at Akita National College of Technology. Nine students were divided into groups of four and five to take the face-to-face and distance lectures.

During the lecture, biometric data were collected with various biometric devices, and the lecture was recorded with a video camera so that the students' status could be checked and the class learning events could be reviewed later. 5 students were given eyeglass-type devices, 2 students were given portable brain activity measurement devices, 1 student was given a portable EEG measurement device, and 4 students were given dermal electrodes. The students were asked to wear the eyeglass-type device, 2 students wore the portable brain activity measurement device, 1 student wore the portable EEG device and 4 students wore the skin potential measurement device. After the class, we also asked the participants to take a PROG test to assess their cross-disciplinary abilities.

By dividing the various biometric data into time series and analyzing them for each learning event that changes with the progress of the class, we analyzed changes in the students' ability to concentrate, etc., that vary with the method of the class. The biometric data of the participants measured included eye potentials, 3D head acceleration, skin potentials, cerebral blood flow, electroencephalogram, and voice data, and the analysis was conducted by the faculty members of the joint research project. The results of the PROG test of the students who participated in the experimental class were also analyzed.

As a result, it became clear that biological information, including the number of blinks estimated from eye potentials, changed depending on the learning event. Differences in biometric information were also observed between the face-to-face and distance lectures. On the other hand, the numerical values of the biometric data and the trends of their changes differed among the participants, making it difficult to evaluate the effects of the learning event based on the numerical values of the measured biometric data.

Conclusions

Since changes in biometric data varied from participant to participant, it is currently difficult to make an absolute evaluation of learning events based on biometric data, but it is possible to make a relative evaluation by capturing changes in participant activity. In the future, we will consider using these quantitative data to create an index for estimating the effectiveness of lesson design.

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CONNECT CURRICULUM TO REALITY VIA CREATION-BASED LEARNING: THE PRE-EXPERIMENT OF THE CLEAR PEDAGOGY AMONG STEM STUDENTS

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Abstract

Students fear examinations. Employees fear deadlines. Exams are based on recalling, while deadlines are based on creation. There is a difference between the two worlds. Our educational systems are insufficiently modernized to prepare students for future jobs in a highly creative society. Therefore, they are bored and distracted in classrooms because of inability to see learning as significant and useful for the future. Therefore, it is essential to include creation activities in the classroom so that students would feel more engaged and actively participate in the learning activities. The instructional design model of CLEAR (an abbreviation for Create, Learn, Extend, Apply, and Reflect) emphasizes curriculum-to-reality links and places creation at the center of the learning experience. This explorative research evaluates the effectiveness of CLEAR using a single group pre-test/post-test pre-experiment research design. A total of seventeen students at the Toyohashi University of Technology participated in a one-month pilot course on the topic of "creative commons open licensing" that utilized both Moodle and Mahara systems. The data came from Moodle system logs, Moodle grade reports, online quizzes, and an online post-course survey. Using SPSS, the descriptive analysis methods illustrated the data distribution and frequency as well as indicated differences in grades and online engagement levels among demographic groups. The results demonstrated that the CLEAR-designed course enhanced students' topical comprehension to at least an above-average level. The demographics (nationality, gender, education level, and specialization) revealed an impact on course grades and engagement levels of students; however, a larger sample size is required to evaluate the validity of this impact. The majority of participants enjoyed the creation-based learning experience and would like to enrol in courses of the similar design in the future. Due to the small sample size and the absence of a control group, it was difficult to credit the grade improvement solely on the design of the course. Randomized controlled trials of the CLEAR-designed curriculum should be implemented to test further the instructional design model and the findings from this research.

Keywords: *STEM, technical education, active learning, pre-experiment, evaluation, creation-based learning, instructional design, pedagogy, creativity*

Introduction

In Japan, STEM (Science, Technology, Engineering, and Mathematics) education becomes increasingly teacher-centered beginning in upper secondary education, and it is rarely taught in relation to real-world applications (Ogura, 2013). As a result, students question the utility of STEM for their future, exhibit a reduced degree of learning joy, and a relatively small fraction consider accepting relevant jobs (Ina et al., 2020; Nakamura, 2015; Ogura, 2013). Youth disengagement in STEM is a worldwide phenomenon. It was argued that our conventional lecture-oriented curriculum significantly contributed to the problem with its emphasis on passive learning and blocking students from appreciating the scope, meaning, and limitations of science (Volpe, 1984). Reforming STEM classrooms is vital because "we depend on STEM graduates to creatively design items, processes, and services to satisfy human needs" (Kanematsu & Barry, 2016, p. 16). Active learning for STEM education has proven to be the most effective pedagogical method swaying away from traditional lecture-based instruction. (Fendos, 2018). Active learning constantly engages students by doing and reflecting on what they are doing (Corrigan, 2013). The obvious advantages of active learning over traditional lecturing to impact undergraduate students' performance in STEM courses have been verified by over two hundred studies (Freeman et al., 2014). Despite the abundant research evidence, the in-class practice of active learning has been slow even in the USA (Fendos, 2018), which indicates a necessity to regularly update STEM teachers on research evidences of active learning.

However, to merely inform teachers of the potential and benefits of active learning as a pedagogic approach is insufficient. It is equally important to introduce the corresponding instructional design processes to teachers so that they can have a prescriptive and normative

orientation towards improving teachers' performance (Bruner, 1966). Since the 1980s exponentially advancing technology have made human life even more intertwined with various technologies resulting in multiple realities of online, offline, and blended modes. Meanwhile, most instructional design models emerged between 1970s and 1990s before the expansion of internet-based media and technologies and are now outdated. The instructional designs of online instruction were much blamed by scholars especially during the COVID-19 pandemic period, when emergency eLearning actions were implemented worldwide (Charbonneau-Gowdy & Galdames, 2021). More research and practices are required to address the misalignment between the appeal of technologies in the digital era and their absence from present instructional design models.

The CLEAR model is a novel instructional design model to enable active learning in classrooms by promoting student-centered creation activities and utilization of various digital technologies (Lin, 2021). CLEAR was an acronym initially for Create, Learn, Extend, Apply, and Remember, but later revised to be for Create, Learn, Extend, Apply, and Reflect. The model is a response to a constantly discussed problem of disengaged students especially online. This explorative study reports the evaluation of an online course, which followed the instructional design model "CLEAR" and required students to deliver their creational works as learning outputs. The associated research aimed to tackle the following questions: (1) Does the CLEAR-designed course effectively enhance students' comprehension of the topic? (2) How do demographics affect students' grades and level of engagement? (3) What do students think of the CLEAR-designed course?

The rest of this article is structured as follows. It will first describe the course structure and research methods. The results and discussion section will present the study's findings and connect them to current literature for additional discussion. The paper will conclude with a summary of the findings, a discussion of its limitations, and suggestions for further research.

Course design and Methods

Following the CLEAR model, an experimental course, *Creative Commons (CC): Create, Distribute, and Use Content on the Internet*, was developed to be a completely online and self-regulated learning experience for its participants. The course's structure of content and assessment can be viewed in Table 1.

Table 1. The structure of the course

	Course resources and activities
(Orientation)	Page: introducing the CLEAR model and learning outcomes URL: assessment and grades Choice: topic familiarity check Forum: Q&A Quiz: Pre-test
Create	Assignment: Submit Mahara page (Grade: 40)
Learn	Page: Lecturing videos and scripts
Extend	URL: External links
Apply	Forum: Peer interaction on assignment (Grade: 10)
Reflect	Forum: Self-reflection on the learning experience (Grade: 10) Quiz: Post-test (Grade: 20)

The creation assignment accounted for fifty percent of the final grade and was graded according to the criteria in Table 2. Students were required to select a medium and create a visual representation to demonstrate what CC licenses are and the compatibility between CC licenses. They then created a web page in Mahara, embedded their representation on the page, and submitted the page for the course's creation assignment in Moodle.

Table 2. The assessment criteria for the creation assignment

	Criteria	Grade
1	Introduce CC licenses overall	5
2	Introduce CC licenses one by one	10
3	Explain the CC License Compatibility Chart	15
4	Apply one CC license to your creation	5
5	Creativity and exceeding expectation	5

The Moodle (version: 3.10.9+) platform served as the Course Management System (CMS) for this course, while the Mahara (version: 21.10.1) ePortfolio management platform served as an additional online place for students to present and submit their creation assignment from. The XML-RPC/MNet authentication enabled Moodle users to log in directly to Mahara. The Maharaws plugin was installed on Moodle to enable the teacher to create a Mahara assignment in the course and the students to select a page or a collection from Mahara and submit it as a response to the assignment.

Throughout the one-month course in January 2022 there was no live teaching, and the instructor was only available when replying to students' questions, communication in forums, or reminding students of deadlines in the course.

Due to the small number of participants this study adopted the pre-experiment (one-group pre-test-post-test) as the research design. A group of 17 students at the Toyohashi University of Technology (TUT) completed the course and received incentives. No control or comparison group was employed.

The students' engagement levels with the course were logged automatically by the system and at the end of the course they completed an online survey. The pre-test (Q1) and the post-test (Q2) shared identical 19 questions, which were available as online quizzes to students in the CMS. The pre-test was taken before the course and the

post-test was taken after students submitted the Mahara assignment. Two scores were recorded and compared.

Descriptive analysis was applied to report students' score change from the pre-test to the post-test, scores in the assignment of creation, and the total course grade's distribution. The demographics of participants, including nationality, gender, department (specialization), education group, were as well reported. Access hours were calculated by summing duration of all active sessions. If the distance between two sessions was less than 30 minutes, it was considered a continuous and active session. The log data were counting the number of logs for each activity in the course (e.g., *C_AssignmentLog* is the count of log records corresponding to the creation assignment page). Finally, student responses to the online survey, distributed through using the service of SurveyMonkey, were analysed through descriptive analysis.

Results and Discussion

Demographics of participant: There were 13 international students and four Japanese students among the seventeen students. Although TUT only had 277 international students compared to 697 local students in 2021, the shortage of Japanese students in this course was primarily because the instruction medium was English, and many Japanese students at TUT lacked confidence in their English skills. There were five Malaysians, two Egyptians, one Indian, one Pakistani, one Mongolian, one Tanzanian, one Chinese, and one Afghan among the thirteen international students. Consistent with the total female student ratio of 12.6% at TUT, the sample consisted primarily of male students (15 out of 17). Such a gender gap can be explained by the facts that girl become less motivated to pursue STEM topics during their adolescent years (Kijima et al., 2021) and TUT only offers degree programs in STEM subjects. Students were from five different faculties at TUT with diverse specializations: mechanical engineering (six), applied chemistry and life science (four), computer science and engineering (three), electrical and electronic information engineering (two), and architecture and civil engineering (two). There were ten undergraduate students, five master's students, and two doctorate students.

Does the CLEAR-designed course effectively enhance students' comprehension of the topic?: 75% of students scored below 10 points on the pre-test (Figure 1). Over seventy-five percent of individuals scored greater than 15 out of 20 on the post-test. Excluding outliers, the gap between the highest and lowest scores decreased from 10.3 (in pre-test) to 4.5 (in post-test). The training had significantly increased students' comprehension of the topic and narrowed the achievement difference between individuals.

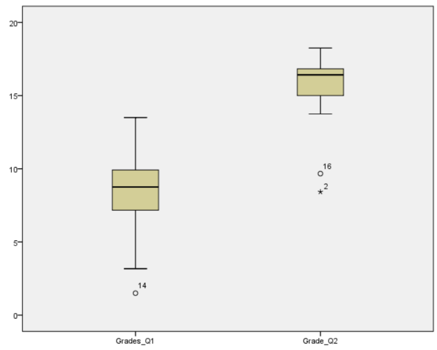

Figure 1. Boxplot of score distribution of pre-test and post-test

The highest final grade in the course was 79, the lowest was 46, and the average was 66 (Figure 2). Approximately 82% of participants scored over 60 out of 80 (equivalent to over 75 points out of 100). Due to the efficiency of the course, the majority of participants were able to comprehend the material at an above-average level.

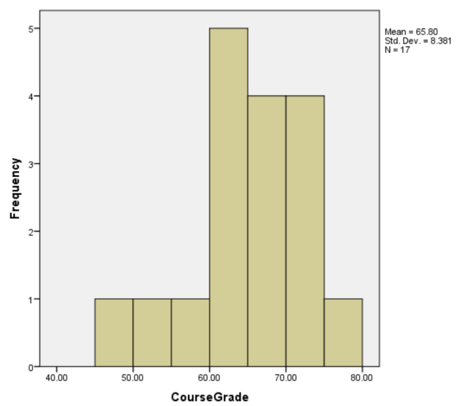

Figure 2. Histogram of final course grades (full score: 80)

More than 75 percent of participants scored greater than 25 out of a possible 40 points on the creation assignment. However, fifty percent of respondents scored below 30 due to difficulty achieving Criteria 3 (Explain the CC License Compatibility Chart) and Criteria 5 (Creativity and exceeding expectations) in Table 2, which were associated with more challenging cognitive tasks. It indicated that students were able to represent elementary information using digital technologies of their choosing; however, half struggled to represent complex information using this method. Although students were given the freedom to choose digital technologies, 71% of them used PowerPoint to complete their creation assignment. This result may be explained by earlier studies indicating that a large proportion of students are not confident or engaged in using digital technologies (Howard et al., 2016; Margaryan et al., 2011; Warschauer & Matuchniak, 2010). Consequently, they tended to use familiar digital tools to create required content.

How do demographics affect students' grades and level of engagement?: The Japanese students improved marginally more on the post-test, while the overseas students performed marginally better on the creativity project (Figure 3.a). It may have shown that Japanese students were more competitive in remembering-oriented tasks but less competitive in creation-oriented tasks compared to their international peers. It may be tied to cultural values such as the fact that preservation is taken very seriously in Japan and seeking changes can be seen as unconstrained and irresponsible (Ge et al., 2021); therefore, Japanese students are accustomed to hearing and strictly following directions.

Female students outperformed male students (Figure 3.b). It may be explained by the course's emphasis on testing verbal fluency (a cognitive function that facilitates information retrieval from memory; abbreviated as VF below) over other mental functions such as mental rotation (an ability to rotate mental representations of two-dimensional or three-dimensional objects), and the fact that female students in general outperform their male counterparts in verbal fluency (Moè et al., 2021).

Students with a higher level of education performed better on the creation assignment and throughout the course (Figure 3.c). The effect of educational level on VF was demonstrated in a prior study, which indicated that the high educational level group performed better than the low educational level group on clustering and switching in three VF modalities: phonemic (PVF), semantic (SVF), and unconstrained (UVF) (Pereira et al., 2018).

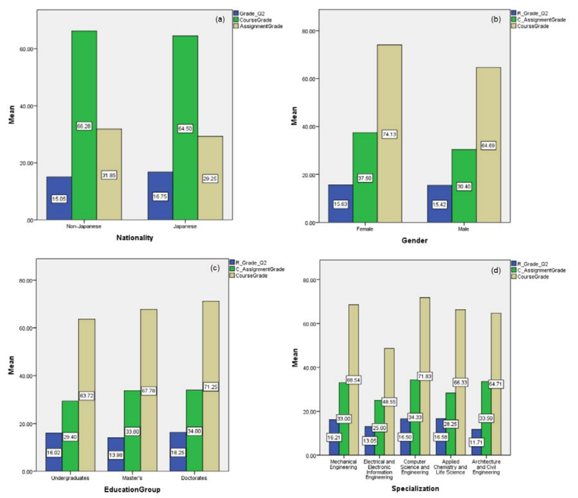

Figure 3. Bar chart of grades by nationality, gender, education group, and specialization

Figure 3.d indicates that students with a background in computer science scored higher than those with a background in other specializations, which is consistent with prior research indicating that digital literacy positively influences the high level of learning outcomes and academic performance (Kerr et al., 2006; Yustika & Iswati, 2020). To determine whether there are substantial accomplishment gaps between demographic groups, correlation analysis will require a bigger sample size.

The Moodle platform's log records indicate the clicking patterns of its online users. Figure 4 (a–d) displayed the frequency of logs related to student interactions with the creation assignment page (*C_AssignmentLog*), lecture pages (*L_ContentLog*), additional URLs leading to extended learning material (*E_LinkLog*), peer-interaction forum, and self-reflection forum (combined as *A_R_ForumLog*). Overall, students engaged with activity pages (e.g., assignments, forums) significantly more frequently than with content pages (e.g., lecture pages, URLs). Higher performance student groups, such as females, Japanese, and students in higher levels of academic programs, had a high participation rate with peer-interaction forums, with an exception found among computer science students (Figure 4). The results agreed with a previous research, which tied age and higher grade point average (GPA) to higher levels of engagement with online instruction and found that female participants tended to have higher levels of engagement than their male peers (Thill et al., 2016). The student demographics were reported to significantly impact student engagement (Al-Nimer & Mustafa, 2022). According to the *E_LinkLog* statistics, the majority of students paid little attention to the extended learning content. However, high-performance students (Japanese, Females, Doctorates, Computer Science students) visited the extended learning content as frequently or more frequently than students with lower performance (Figure 4.d), indicating a potential correlation between inquisitiveness (or willingness to learn more) and academic performance. This finding is consistent with the findings of another study: students who scored higher also possessed higher levels of inquisitiveness (Blumner & Richards, 1997).

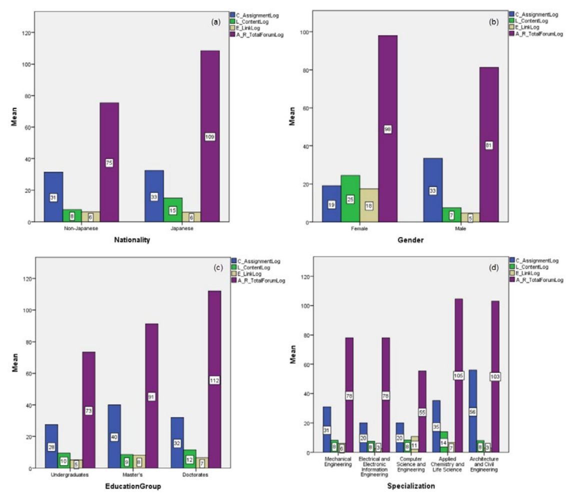

Figure 4. Bar chart of log frequencies by education group

What do students think of the CLEAR-designed course?: All respondents to the post-course survey

agreed that the course was well-designed, engaging, and intellectually demanding, and that it was a success (Figure 5).

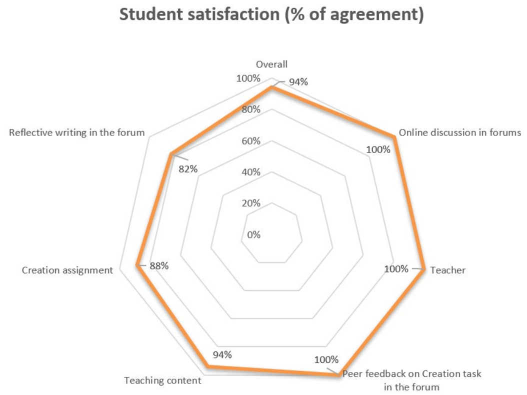

Figure 5. Student satisfaction of each aspect of the course

They were practically unanimous in their approval of the online discussion activities, the instructor, receiving peer feedback on their creation outputs, and the educational content's quality. Approximately 94% of participants were pleased with the training and loved the experience. Students evaluated the creation assignment as the most time-consuming activity in the course, and only 71% felt that it was simple to complete it, but they also commented that the assignment was valuable and boosted their learning in the course (94 percent agreed).

Conclusions

At the Toyohashi University of Technology in Japan, a small sample of 17 STEM students were examined to determine the effectiveness of an experimental course based on the CLEAR instructional design model. The majority of participants were satisfied with the CLEAR-design online learning experience. Through the course, students enhanced their topical knowledge and displayed a high level of online engagement with the CMS. It also appeared that students who were female, had a higher level of education, or had greater digital literacy profited more from the creation-based learning experience. Although this online course of creation-based learning was favourably received by students, additional formal evaluations are required to confirm its efficacy for a larger audience. Due to the limited sample size and lack of a control group, it was difficult to attribute the performance improvement simply to the course's design. To further test the CLEAR instructional design model and the findings of this study, randomized controlled trials of the CLEAR-designed curriculum should be conducted.

Acknowledgements

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Home-based Learning (HBL) during Covid-19: Challenges Faced by Learners and Strategies to Make HBL More Effective

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Abstract

Covid-19 has spread to nearly all parts of the world. In a bid to contain this pandemic, measures such as quarantines and lockdowns were implemented. This is no exception in Singapore. All schools commenced full home-based learning (HBL) on 8 April 2020 while the polytechnics did so when the new academic year began in mid-April. Till then, full HBL had never been implemented in the education sector in Singapore. Previously, students were only expected to engage in some form of self-directed learning, covering approximately 20% to 30% of the content. As home-based learning was completely foreign to learners when it was first implemented, as practitioners, we were concerned with how students would cope and respond to this novel mode of learning. In particular, we wanted to find out our learners' views regarding their preferred mode of learning, the effectiveness of HBL and challenges faced in HBL. Students from the School of Business Management, Nanyang Polytechnic participated in this study. 210 learners from the Polytechnic Foundation Programme, Year 1 and 2 across various diploma programmes completed a Google Form questionnaire. The results showed that learners generally preferred face-to-face learning to HBL, given that face-to-face communication facilitates a smooth exchange of information. Moreover, full HBL was implemented during the first semester of a new academic year, making it difficult for new IHL learners to transit from secondary to tertiary education. Some challenges learners experienced included poor internet connectivity and short attention spans during e-tutorials, with many of them constantly seeking stimulating experiences elsewhere. There were, however, some learners who preferred e-tutorials as they could save time and money, and learn comfortably at home. Despite the challenges, HBL can be enhanced by incorporating some e-learning activities, and using gamification and videos to make it effective and enjoyable to learners. Going forward, even though full HBL may not continue, blended learning will be the preferred pedagogical approach of IHLs. A study of similar nature or a focus group interview can be conducted with a new cohort of students to validate the current research findings.

Keywords: *Covid-19, home-based learning, self-directed learning, e-learning, face-to-face learning, e-tutorials, face-to-face tutorials*

Introduction

Covid-19 which emerged in early 2020, has spread to nearly all parts of the world. In a bid to contain this pandemic, measures such as quarantines and lockdowns were implemented. This is no exception in Singapore; instead of calling it a lockdown, the government preferred the term, 'circuit breaker'. For all schools and institutes of higher learning, full home-based learning (HBL) commenced on 8 April 2020. However, polytechnics only implemented home-based learning in mid-April as that was when the new academic year began.

Up until now, full home-based learning has never been implemented in schools nor in institutes of higher learning in Singapore. Previously, students were only expected to engage in some form of self-directed learning covering approximately 20% to 30% of the content they need to acquire.

It was during the semester break in March 2020 that NYP staff were informed that home-based learning will be implemented in the new academic year. Staff members were to record their lectures and make them available on BlackBoard, the learning management system used by NYP. For tutorials, staff were to familiarise themselves with Zoom as a platform to conduct synchronous online lessons.

Methodology

As home-based learning was completely new to learners when it was implemented in April 2020, as practitioners, we were curious as well as concerned with how students would cope and respond to this novel medium of learning. In particular, we were interested to find out our learners' views regarding the following:

a. Is home-based learning effective?
b. How could home-based learning be made more effective?

c. Do learners prefer home-based learning over face-to-face tutorials on campus or vice versa? What are their reasons?
d. What challenges did learners face in home-based learning?

The focus of this research study is limited to students from the School of Business Management, Nanyang Polytechnic. Students from the polytechnic foundation course, Year 1 and 2 across various diploma programmes participated in this study.

Data were collected using a questionnaire on Google Form. To complete the questionnaire, students were given the weblink to access the questionnaire. A pilot questionnaire survey was administered to a class of twenty students. None of the students sought clarification or had any queries regarding the questions. Therefore, the questionnaire remained unchanged and was subsequently administered to the rest of the students. A total of 210 students participated in the questionnaire survey.

Literature Review

As noted above, other than engaging in some form of self-directed learning, students in Singapore have never participated in full home-based learning until now. A keyword search on the term, 'home-based learning' yielded either newspaper articles or articles from the Ministry of Education, Singapore website, or home-schooling. However, not only is home-schooling uncommon in Singapore, but it is also different from home-based learning.

Reading the then Minister of Education, Mr Ong Ye Kung's Facebook page shed much light on home-based learning. A day before full home-based learning began, the minister's post on Facebook revealed that he believed that home-based learning could help students develop a precious life-skill. "The strength of HBL is that it encourages the student to exercise initiative and practice self-directed learning. If we can get our children to be acquainted with that idea, this period of HBL would have gifted them a precious skill for life" (Ong, 2020a).

The then education minister is however not in favour of extending home-based learning as "… HBL is a fall back when schools are suspended; it cannot be a prolonged substitute for school" (Ong, 2020b). As Lim (2021) aptly sums up, "How well this home-based learning experience goes hinges on four factors in the home – space, the availability of devices, Wi-Fi speeds and parental skills." Many parents themselves were working from home and found themselves having to manage their own work schedule and their children's learning plan. What was once a home needed to be transformed into a shared work cum learning area. It is even more of a challenge if this shared area is small because

"… children will start to hush one another when they are unable to hear their respective teachers clearly, even with headphones on. Throw in a working parent's conference call with her boss and you will have a very frazzled household. Finding enough room for every child to settle comfortably with their devices and hard-copy reference materials, and to complete assignments while listening to online instructions" is another major challenge (Lim, 2021).

Besides this, home-based learning may be especially trying in homes where numerous family members share a laptop or desktop computer. Thankfully, SGBono, a volunteer group, offered free laptops and iPads to low-income families. The Ministry of Education (MOE) has also loaned out some 3,300 devices such as tablets and laptops, and over 200 dongles for Internet access, to students who require them for home-based learning (Ang, 2020).

As most people are staying home to either work or learn during this period, Wi-Fi speeds may have slowed down considerably when the entire family is accessing synchronous live chats simultaneously. Students whose homes do not have access to high-speed broadband plans or have reliable connections would have struggled with home-based learning, where the audio cuts in and out and the video lags.

Parents also differ in their comfort level when it comes to dealing with technology. Hence, tech-savvy parents would be more confident and at ease in helping their children negotiate various learning management systems and their associated processes. The availability and ability of parents to provide support can diverge significantly across households when students encounter difficulties with their home-based learning (Lim, 2021).

As a result of Covid-19, HBL was implemented as a last resort because face-to-face lessons could not be conducted. This research study is therefore timely as an investigation on students' perception, its effectiveness as well as ways HBL could be improved, should there be a need to implement it in the future.

Results and Discussion

Having provided the background information and methodology of the study, this section discusses the following findings:
1.Effectiveness of E-tutorials (HBL) Compared with Face-to-face Tutorials
2.Effectiveness of On-the-spot Quizzes to Gauge Understanding of Concepts in E-tutorials (HBL)
3.Effectiveness of Group E-activities in E-tutorials (HBL)
4.Effectiveness of Learning Aids
5.Completion of Fewer Tutorial Questions
6.Q&A Time
7.Preference for e-Tutorials/ Face-to-Face Tutorials
8.Reasons for Preferring E-tutorials (HBL)
9.Attention Span during E-tutorials (HBL)
10.Multitasking during E-tutorials (HBL)
11. Problems Faced during HBL

1. Effectiveness of E-tutorials (HBL) Compared with Face-to-face Tutorials

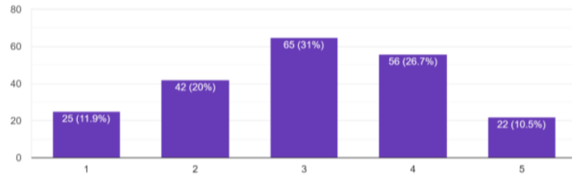

Figure 1. E-tutorials are equally effective in helping me learn when compared with face-to-face tutorials

As shown in the bar chart above, 31.9% of the learners strongly agreed or agreed to the statement while 31% of them were neutral, and 37.1% learners disagreed and strongly disagreed.

. Slightly more learners leaned towards face-to-face tutorials. First, face-to-face communication allows for a better exchange of information since both speakers and listeners can see one another, interpret body language and facial expressions. Therefore, having the ability to see the people you are speaking to and interpret their reactions is extremely important.

Another possible reason why learners considered HBL to be less effective compared with face-to-face learning is that this is the first-time learners were made to learn 100% online. Thus, they may still be getting used to HBL. For the majority of respondents, this is the first semester for learners at an IHL. The transition from studying in a secondary school to a tertiary institution is a huge leap. Learners must feel comfortable with one another; face-to-face meeting helps with building rapport between learners and the lecturer. Establishing rapport with and between learners is also important as this could motivate them to come to class more often, and to remain focused in class. Thus, rapport seems to facilitate both student motivation for learning and their enjoyment of the course as well as enhance learner receptivity to what is being taught. (Buskist and Saville, 2001)

2. Effectiveness of On-the-spot Quizzes to Gauge Understanding of Concepts in E-tutorials (HBL)

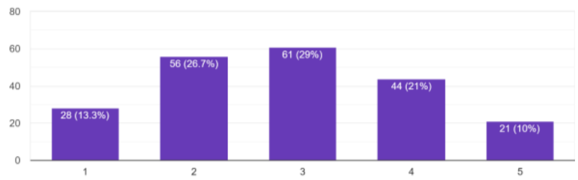

Figure 2. I can learn better through e-tutorials if there are on-the-spot quizzes to gauge my own level of understanding of the concepts learned.

Based on the responses shown in the above diagram, tutors could consider incorporating on-the-spot quizzes in e-tutorials as 40% of the respondents strongly agreed or agreed that this could make their learning more effective. A quiz is also a learning moment in itself as quizzes allow learners to gauge how much they have learnt and clarify any doubts with their tutors. This is echoed by Brame and Biel (2015). “Quizzes can promote deeper engagement with the content, further the development of important learning skills, and provide teachers and learners with feedback that promotes learning.”

3. Effectiveness of Group E-activities in E-tutorials

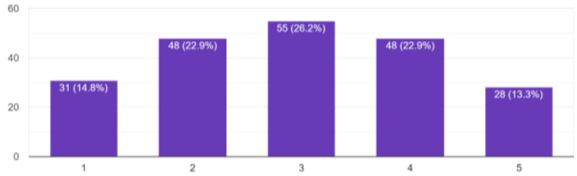

Figure 3. I can learn better through e-tutorials if there are group e-activities to work together with my classmates.

37.7% of the learners strongly agreed or agreed to the statement while 26.2% were neutral. The remaining 36% of learners strongly disagreed or disagreed with the statement.

When learners work in groups, they have shown increased individual achievement compared to working alone. Furthermore, group work enhances communication and other professional development skills (Taylor 2011).

Thus, it is somewhat baffling to find that the respondents were divided as to whether group e-activities were beneficial in helping them learn. One reason could be that whether group activities benefit learners largely depends on the kind and quality of activities, and the participants. Well-designed activities and highly driven learners could reap the benefits of group activities while poorly designed group activities could frustrate and hamper learning. Members in group activities also play a significant role. Passive or disinterested learners, such as free riders, who are reluctant to participate or contribute to the group task would leave their members discouraged and defeated. The synergistic effect of group activities would thus be missing in these group activities.

4. Effectiveness of Learning Aids
   i. Relevant Videos

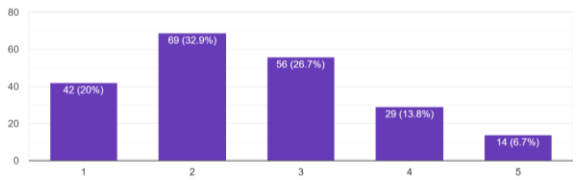

Figure 4. I can learn better through e-tutorials if there are relevant videos shown to deepen my understanding of the topic.

52.9% of the learners strongly agreed or agreed while 20.5% strongly disagreed or disagreed. The rest, 26.7% were neutral. Learners generally believe that watching videos facilitates learning. Videos that show relevant information can be very effective at increasing interest

and facilitating discussions among learners. Carefully selected or well-produced videos that contain information that piques curiosity or make connections to learners' life or the real world can increase motivation to learn and participate. Another advantage is that videos can enhance retention especially when the facts are applied to solving a particular problem. Explanations can be done to show the "how" and "why" of something being taught. Videos that make use of associations between texts and images and analogies to get a point across can be very effective learning aids (Honig-Goepp, 2015).

ii. Games

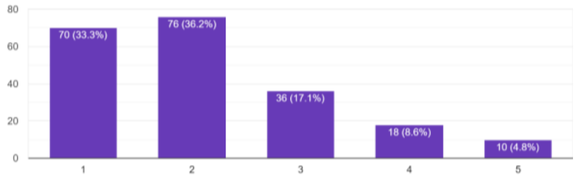

Figure 5. I can learn better through e-tutorials if there are relevant games to play (such as Kahoot) to deepen my understanding of the topic.

As shown in the above pie chart, 69.5% of the learners strongly agreed or agreed while 17.1% were neutral. The remainder, 13.4% either strongly disagreed or disagreed.

According to Mulkeen (2018), when games are used in learning, learners are better engaged. Furthermore, games help to change perceptions and attitudes and develop skills through a practical, applied, and thoroughly hands-on approach to learning. Bearing in mind the numerous benefits that learners could reap, well-designed games could be incorporated into online tutorial sessions The five most compelling benefits of gamification of learning are that it:

a) helps create exciting, educational, and entertaining content.
b) makes learning informative and exciting due to its interactivity. Role-play and competitive elements add an immersive angle, which, if set up well, can quite simply make learning fun.
c) offers learners the opportunity to engage with content in an effective, informal learning environment. If learners get excited about learning, they are more likely to retain information.
d) gives learners the natural high and that 'high' helps with better retention of knowledge. The brain releases dopamine into the body when learners win a game which makes them feel good.

5. Completion of Fewer Tutorial Questions

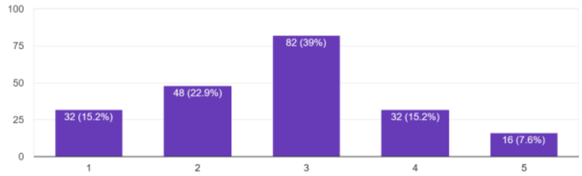

Figure 6. I can learn better through e-tutorials if there are fewer questions to complete for e-tutorials.

Most learners were neutral (39%) or strongly agreed or agreed (38.1%) with the statement. Only a minority of 22.9% strongly disagreed or disagreed. Perhaps, whether better learning takes place through e-tutorials is not dependent on the number of tutorial questions but on the following.

First, it is the quality of tutorial questions over the quantity that matters. Second, it is also dependent on whether learners have time to prepare answers for tutorial questions and not on the number of questions. Lastly, it is dependent on the type of module. For modules like statistics or accounting, learners seem to be able to better grasp concepts if there are more questions to practise on.

6. Q&A Time

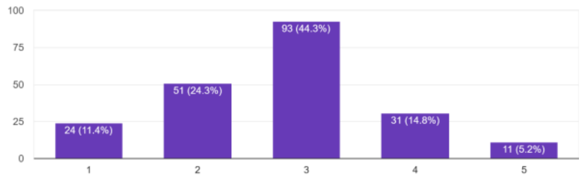

Figure 7. I can learn better through e-tutorials if there is more time allocated for asking questions.

Most learners (44.3%) were neutral while slightly more than a third (35.7%) strongly agreed or agreed with the statement. A minority of 16% strongly disagreed or disagreed.

Based on our teaching experience, few learners raise questions during or after tutorials. This could be a result of the rather lengthy two-hour Zoom tutorial session. Students may have lost their attention and thus may be reluctant to ask questions. For those who raised questions, the questions were mostly related to the submission requirement of in-course assessments. Perhaps, learners would be encouraged to ask questions if they were given more time to reflect on concepts learnt rather than cramming them with too much content.

7. Preference for e-Tutorials/ Face-to-Face Tutorials

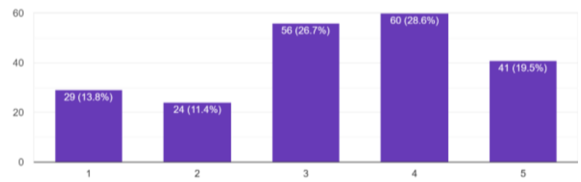

Figure 8. I prefer e-tutorials compared to the normal face-to-face tutorials that take place in classrooms.

Almost half of the respondents (48.1%) strongly disagreed or disagreed while 26.7% of them were neutral. About a quarter (25.2%) strongly agreed or agreed with the statement.

This survey was administered after learners had undergone between eight to ten weeks of HBL. One possible reason for this finding is that learners were still experiencing teething problems and were still getting accustomed to HBL. Their dislike or preference for e-tutorials over face-to-face tutorials will be further examined below.

8. Reasons for Preferring E-tutorials (HBL)

The top six reasons that the respondents preferred e-tutorials over face-to-face tutorials are that learners:

a) do not have to commute to NYP (151 respondents; 71.9%);
b) can learn in the comfort of their home (150 respondents; 71.4%);
c) can save money staying at home (118 respondents; 56.2%);
d) can remain silent most of the time (67 respondents; 31.9%);
e) do not need to interact with their classmates (39 respondents; 19.5%);
f) do not need to interact with their tutor (33 respondents; 15.7%).

The reasons cited are totally understandable. Commuting to the institution takes time. Some of the learners stay a considerable distance away and could take up to an hour and a half to commute each way. Also, many of them were fearful of contracting the COVID-19 virus since the majority of learners commute using public transport. Thus, they preferred to learn in the comfort of their home. Being at home brings with it many conveniences such as being able to prepare simple meals and having access to snacks and beverages at home. These learners could therefore save a significant amount of money (118 respondents cited this). This is an important consideration since most of them still get their pocket money from their parents or guardians. Some of them also work part-time for additional income. Furthermore, not having to commute to the polytechnic also means that they were able to sleep in.

As for preferring to remain silent and not having to interact with their classmates or tutor in face-to-face tutorials, these responses could have come from the shy or introverted learners. Regardless, most learners are rarely forthcoming and seldom volunteer to answer questions despite being reminded that they would accumulate class participation points. Learners would only answer questions when they were specifically requested by their tutor to do so.

Learners who preferred e-tutorials cited practical reasons such as not having to commute as well as reducing their expenses when they learnt from home. Those who remained silent believe that they could best learn by listening and absorbing as much information as they could during each tutorial session.

9. Attention Span during E-tutorials (HBL)

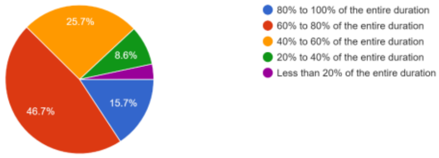

Figure 9. During e-tutorials, I can focus on the lesson about…

Only 8.6% of the learners cited that they could focus on 80% to 100% of the lesson. 46.7% of the learners cited they could only focus on 60% to 80% of the lesson while 25.7% cited 40% to 60%. If the majority could concentrate on 60% to 80% of their HBL tutorial sessions, this is considered no mean feat as virtual meetings can be exhausting. According to Dr Lim Boon Leng, a psychiatrist from Gleneagles Hospital, during virtual meetings, the brain changes due to electrical activity in the brain's neocortex as well as dopaminergic and cholinergic neurotransmission, although these changes are still not well understood. Furthermore "when a Zoom meeting becomes boring, dopamine levels are likely to drop and the positive reinforcement to stay focused slowly disappears. As such, there is a natural urge to maintain the level of dopamine by seeking stimulating experiences from the surroundings". Therefore, it is not surprising that learners become distracted and lose concentration when they start to feel bored (Khoo, 2020).

It is thus pertinent to sustain learners' interest through quizzes, gamification and by showing relevant videos during e-tutorials.

10. Multitasking during E-tutorials (HBL)

When they were learning online,

a) 95 (45.2%) cited they were accessing social media;
b) 93 (44.3%) cited they were doing something else;
c) 82 (39%) cited they were chatting with friends;
d) 72 (34.3%) said they were listening to music

These findings are hardly surprising as some of the learners had just transited from secondary schools. In addition, once these younger learners found their online meeting unengaging, the ability to stay focused disappeared. Therefore, it is not surprising that learners become distracted and lose concentration when they felt bored.

11. Problems Faced during HBL

The following problems encountered by learners hindered their HBL.

a) 138 (65.7%) cited internet connection problems;
b) 100 (47.6%) said they were distracted by family members;
c) 81 (38.6%) cited noisy environment
d) 79 (37.6%) cited technical issues such as microphone not working

e) 33 (15.7%) cited unsuccessful attempts to log into Zoom

The top problem encountered while learning from home was poor internet connection. Parents and siblings also tapped on the same network and thus learners could have experienced lags in their Zoom meetings. Almost 40% cited that their learning environment was noisy and that they were distracted by their family members (47.6%). This is obvious as the majority of Singapore residents live in a HDB flat, the average size being between 600 to 1000 square feet shared by several members.

Conclusions

Based on the above findings, the following conclusions can be drawn.

First, most learners deemed e-tutorials less effective compared to face-to-face tutorials. Face-to-face communication facilitates a smooth exchange of information as body language and facial expressions can be used to enhance mutual understanding. Moreover, full HBL was implemented during the first semester of a new academic year, making it difficult for new IHL learners to transit from secondary to tertiary education. Learners were thrown into an unfamiliar mode of learning, especially when they had yet to establish rapport with their new classmates and tutors. As most learners are of the age of 16 – 17, they simply lacked the maturity to take ownership and exercise self-discipline in HBL.

Second, only a quarter of the learners expressed their preference for e-tutorials as they could save money and time spent on travelling, and learn comfortably at home. The more introverted learners were also relieved to have lessons conducted virtually (HBL) as they could remain silent throughout the lesson. The majority of learners still preferred face-to-face tutorials on campus as they could interact and better communicate with their peers and tutors. Many learners also experienced short attention spans during e-tutorials; many of them were constantly seeking stimulating experiences elsewhere: accessing social media, multi-tasking, chatting with friends, and etc. The tutorial-room setting in IHL allows learners to stay focused on their learning as some of them had to share space with their siblings and parents who work from home. In addition to physical space constraints, many learners also faced poor internet connectivity at home with many of them having to share the same network with other family members.

Third, HBL experience can be enhanced by incorporating some e-learning tools and activities. Many learners agreed that on-the-spot quizzes could make learning more effective as it allows them to check their understanding of skills and concepts taught. Furthermore, feedback obtained from quizzes is useful for educators to improve their e-learning content. While the use of breakout rooms was commonplace during HBL, learners, however, did not show a strong preference for it. To reap the benefits of group work such as quality work and enhanced communication, the design of the activities should take into consideration task difficulty and free-ridership issues. Video-watching is another preferred activity by more than 50% of the learners. Well-curated or produced videos can enrich learning and increase learner’s motivation, which makes it a recommended activity to include in HBL to break the monotony of the classroom. Close to 70% of the learners agreed that relevant games during HBL could help to deepen their understanding of the lesson. Like group e-activities, games need to be well-designed so as to reap benefits such as better learner engagement and motivation. Last but not least, time should be allocated for Q&A as around 80% of the learners were neutral or in favour of it. HBL may be challenging for learners to fully understand certain complex skills and concepts so time should be given for learners to clarify their doubts.

Going forward, even though full HBL may not continue, depending on how the Covid-19 pandemic evolves, blended learning will be the preferred pedagogical approach of IHLs. A study of similar nature or a focus group interview can be conducted with a new cohort of students to validate the current research findings.

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TRANSFORMING POLYTECHNIC ENGINEERING EDUCATION BY INCORPORATING EMERGING TECHNOLOGIES IN THE CURRICULUM

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Abstract

The Fourth Industrial Revolution has brought upon the need for digitisation of the manufacturing process and the impact of the Revolution on economies, jobs and skills is considerable with significant shifts in job roles and the corresponding skills are required. In the future of work, shelf life of skills sets will decrease to five years. Individuals will have to update their skills six times throughout their careers to remain relevant at their workplace (Deloitte, 2017). There is also a pressing need to update the curriculum for industry currency.

This paper provides an overview of the curriculum transformation of the Automation & Mechatronic Systems (AMS) Diploma offered in Ngee Ann Polytechnic (NP) in response to changes in the industry, accelerated by the Fourth Industrial Revolution and emerging technologies. In order to enhance students' career readiness and resilience for the future economy, industry scanning was conducted through various sources such as the Industry Transformation Map (MTI, 2017), Singapore's SkillsFuture Framework and feedback from industry partners.

To adapt to the evolving landscape in the industry, the AMS course team updated and aligned the curriculum with practices and emerging trends in the industry into its stepped progression design of the curriculum. In the first year of studies, students would build their foundation in core engineering skills. In the second year, students would deepen and broaden knowledge in automation and emerging technologies such as Industrial Internet of Things (IIoT), Cloud Computing, Data Analysis & Visualisation, Computer Vision and Augmented Reality. In the final year of studies, students would have the opportunity to learn advanced robotics and autonomous vehicle to prepare them for the industry before embarking on an internship programme or Final Year Project.

This paper focuses on the Integrated Real-world Project 3 (IRP3) module, to showcase how emerging technologies were infused in the module curriculum. In IRP3 module, students designed Augmented Reality applications for Machines Operation and worked on the IIoT project, where they had to design and implement solutions on Industrial Machines for remote monitoring to improve productivity. Students' feedback on the curriculum had been encouraging. Students commented positively on course relevancy and currency to real-world industrial applications. Students also remarked that the course projects were critical in developing their technical skills in emerging technologies and generic skills such as problem-solving, reflective thinking and self-directed learning.

Keywords: *Transformation Engineering Education, Emerging Technologies, Real-world Project, Automation and Mechatronic*

Introduction

Industrial 4.0 and The Need for Curriculum Currency

The Industrial Revolution, which started in the latter half of the 18th century transformed economies from agriculture to manufacturing by leveraging on new technological inventions to make production more efficient. Throughout the years, major transformation in technology have impacted how economies have grown. The current phase, which is called the Fourth Industrial Revolution (Industry 4.0) focuses heavily on interconnectivity, automation, machine learning, and real-time data (Epicor, 2022). This new phase of the industrial revolution brought about new skill sets in addition to those that were required from the automation-focused Third Industrial Revolution (Industry 3.0). Future skills and technologies for Industry 4.0 include the Internet of Things (IoT), Cloud Computing, Big Data, Artificial Intelligence, and machine learning, Virtual and Augmented Reality, Robotics, and Self-driving vehicles (Carroll, 2022).

With the consideration to ensure graduates remain relevant in the Industry 4.0 environment, the curriculum

for the Diploma in Automation & Mechatronic Systems (AMS) by School of Engineering, Ngee Ann Polytechnic (NP) was reviewed and transformed to maintain its relevancy to the industry. Prior to the review, the pre-transformed AMS curriculum was a 3-year, broad-based curriculum that combines the skills and knowledge of Mechanics, Electronics and Programming. Students are trained in the domain-specific competencies as shown in Figure 1:

Figure 1: AMS Domain Specific Competencies

Graduates from the AMS course embarked on careers such as Assistant Engineers in Precision Engineering, Electronics, Aerospace, Marine & Offshore, Sea Transport, Food Manufacturing and Energy & Chemical.

It was observed that emerging skill sets required for digitisation of the manufacturing process (i.e. Industrial Internet of Things) are not covered in the pre-transformed AMS curriculum. Only some students have the opportunity to attain these skills through implementing their Final Year Projects.

Therefore, there was a need to review the AMS curriculum to ensure that all students have opportunities to develop these emerging skills sets and be industry-ready and relevant. Emerging Technologies were identified and reviewed on their relevance to the curriculum to enhance student's career readiness and resilience for the future economy.

Industry Scanning of Emerging Technologies

As part of the AMS curriculum review, the course team conducted an "industry scanning" to review current industry needs and requirements. The AMS course team reviewed various sources such as the Industry Transformation Map (MTI, 2017) and Singapore's SkillsFuture Framework. The Singapore Industry Transformation Map (ITM), a roadmap to drive industry transformation was introduced by the Ministry of Trade and Industry in 2016 with the aim of integrating productivity improvement, skills development, innovation, digitisation, and internationalisation (MTI, 2017). The Skills Framework is an integral component of the Industry Transformation Maps which provides key information on the sector, career pathways job roles, and emerging skills required for the job roles (SkillsFuture, 2022).

Under each Skills Framework sector, different desired attributes and Skills in demand and their emerging skills are listed. The Skills and Competencies identified for each of the job roles fall under two broad classifications: Technical Skills and Competencies (TSCs), and Critical Core Skills.

AMS course is mapped to the Skills Framework for Precision Engineering and Electronics sectors, where the emerging trends & skills are identified as shown in Figure 2.

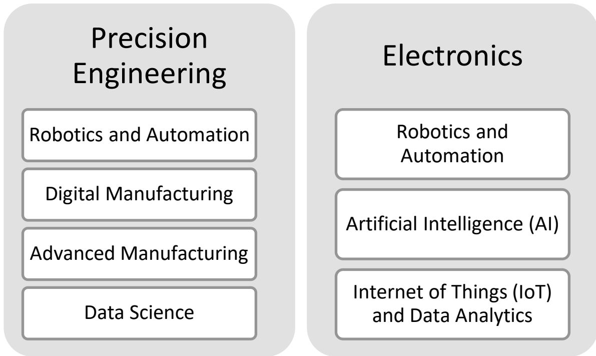

Figure 2: Emerging trends and skills in the Precision Engineering and Electronic sectors.

Upon identifying the emerging trends, the course identifies the relevant TSCs under each emerging skill to fulfill the listed knowledge and abilities. Figure 3 shows the TSCs in the Robotics and Automation and Digital Manufacturing emerging skills.

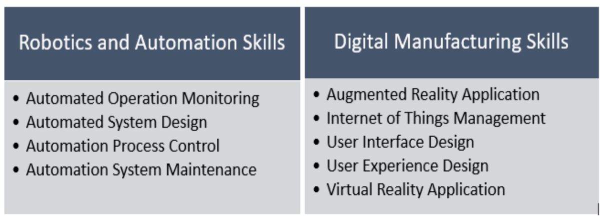

Figure 3: TSCs under Robotics and Automation & Digital Manufacturing Skills

Besides industry scanning through Singapore's SkillsFuture Framework, the course team also identified emerging technologies such as Autonomous Vehicles and mobile robots' technologies from consultations with industry partners which were added to the revised curriculum to ensure relevancy.

Stepped Progression Design of the AMS Curriculum

Upon identification of the Technical Skills and Competencies (TSCs), Critical Core Skills knowledge and emerging technologies from Skills Framework and close engagement with industry partners, the course team updated and aligned the curriculum with practices and emerging trends in the industry in its stepped progression design of the curriculum.

Under NP’s formal stepped progression, in the first year, students build a foundation with guided learning of concepts, theories, and skills to step students into a new field and broad-based development. In the second year of studies, the focus would be on deepening and broadening knowledge and skills where there will be reduced guidance and increased learning through exploration, collaboration, doing, and reflection. Finally, in the third year, students will be enabling their performance with increased self-directed opportunities to integrate knowledge and skills to apply to industry-based problems and real-world issues.

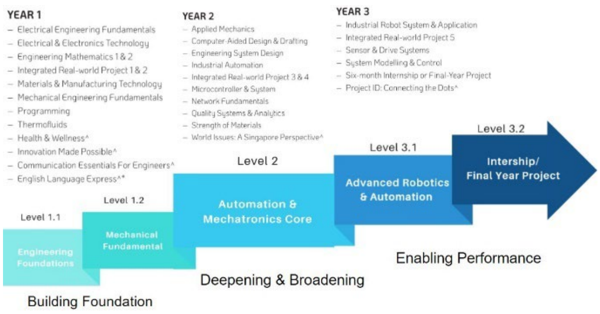

Figure 4: AMS Stepped Progression Model

AMS Stepped Progression Model can be seen in Figure 4. In the first semester of Year 1, AMS students will be building a foundation in Engineering with fundamental modules in Mechanical, Electrical/ Electronics, and Programming under common engineering modules. After the first semester, engineering students are streamed into the Electrical and Mechanical Track. As the AMS course is under the Mechanical Track, students would study modules to build their fundamental modules in Mechanical Engineering from modules such as Materials, Manufacturing processes, Thermodynamics, and Fluid Mechanics.

Students in Year 2, would deepen and broaden their knowledge in Automation and Mechatronics technologies in core modules and Integrated Real-world projects. Deepening of Mechanical knowledge is evident in modules such as Applied Mechanics, Strength of Materials, Engineering Systems Design, and Computer-Aided Design and Drafting. Students are broadened with knowledge in robotics and automation with the introduction of modules such as Industrial Automation, Microcontroller & System, and Network Fundamentals. Hands-on experiential learning of emerging technologies such as Industrial Internet of Things (IIoT), Cloud Computing, Data Analysis & Visualisation, Computer Vision and Augmented Reality are introduced in the Integrated Real-world Project 3 & 4 (IRP3 & IRP4) modules.

In the final year of studies, students would integrate knowledge and skills to apply to industry-based problems and real-world issues. Students would have the opportunity to learn Advanced robotics & Automation in modules such as Industrial Robot System & Applications, Sensor & Drive Systems, and System Modeling & Control. Emerging skills in the Autonomous Vehicle are gained through the Integrated Real-world Project 5 (IRP5) module.

The TSCs for the Robotics and Automation Skills cover the design and commission of automated systems, their operation and maintenance. This is implemented in AMS core modules in Industrial Automation, Integrated Real-world Project 3 (IRP3), and Industrial Robot System & Applications. Emerging Technologies in IO-Link, Augmented Reality, and Industrial Internet of Things (IIoT) are incorporated into the modules.

Infusing Emerging Technologies in Integrated Real-world Project 3 (IRP3) module

The Integrated Real-world Project 3 (IRP3) module will be used to showcase how emerging technologies from industry scanning are incorporated into the curriculum. The IRP3 module uses the Modular Production System (MPS) in Figure 5 to provide horizontal integration of knowledge acquired during the semester and incorporate emerging technologies.

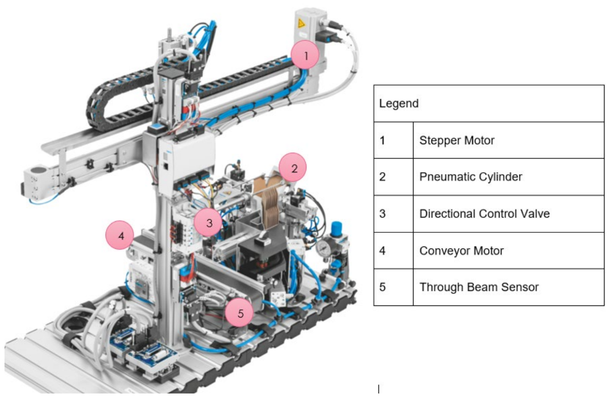

Figure 5: Modular Production System (MPS)

Under the SkillsFuture’s Precision Engineering sector, Digital Manufacturing Skills and Robotics and Automation Skills are listed as the emerging skills for the job roles. TSCs in the emerging skills with the technical competencies are listed as shown in Figure 6.

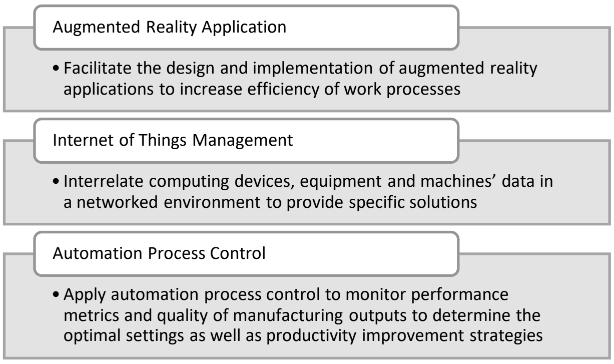

Figure 6: TSCs for Emerging Skills

Knowledge and abilities of the Augmented Reality Application TSC are referenced during the design of the AR component of the module. In order to fulfill level 3 of the TSC Proficiency, students will have to facilitate the development of AR applications by supplying work-specific information and instructions. Development of the module also involved researching and learning how major industry players develop their AR applications to train their operators/technicians to use machinery in their factories.

Industrial Internet of Things (IIoT) knowledge was introduced in the module where students learned to set up and integrate an industrial network system for communication between industrial controllers, the Industrial Internet of Things (IIoT) Gateway, and the computer. Students will also learn Machine to Machine Communication Protocols and perform Data Visualization of the results. In order to ensure its currency and relevancy to the industry, industry visits were conducted to understand the latest industry trends and how the industry digitise machines with the deployment of IIoT on existing machines. The content was subsequently aligned to Level 3 of the Internet of Things Management and Automation Process Control TSCs for the Skills Framework.

Results of IRP3 Implementation

It is noted that students learn actively by doing and reflecting on their experiences. In the IRP3 assignments, students are presented with real-world scenarios that they would need to research and solve. With the knowledge and skills that the students had acquired during practical sessions, they integrate their learning by working for an extended period to generate the product.

In the AR assignment, students first understand the user needs and explore the user requirements (i.e an AR app that guides the operator to handle the machine). In the process of developing this AR app, students developed creative thinking skills and cultivated an attitude of inquisitiveness in finding solutions to meet the user's needs as shown in Figure 7.

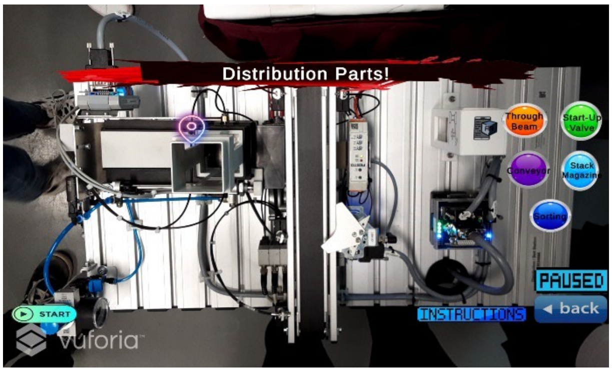

Figure 7: AR Application of a Distribution Conveyor System developed by students

For the IIoT assignment as shown in Figure 8, students were given a scenario of a real-world manufacturing factory. They were tasked to use Industry 4.0 tools and concepts solutions to improve productivity to monitor the presence of the workpiece and the machine status.

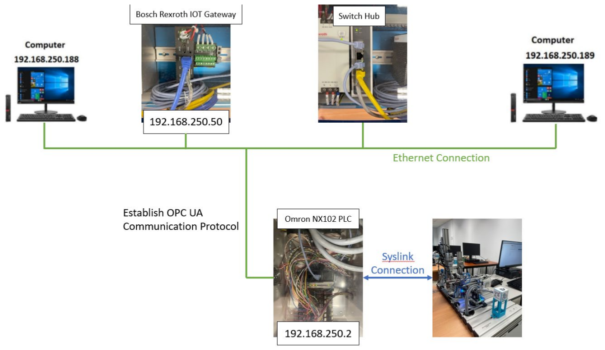

Figure 8: IIoT Assignment

The end of Semester Practical Test also incorporated authentic scenarios and assessment questions from Worldskills Industry Related Test Project to reflect current industry standards and higher assessment rigor that stretches students' capabilities which includes optimizing the codes to reduce production test time to increase overall throughput (which in turns generate more profit) for the fictitious company.

Figure 9: IRP3 end of Semester Practical Test

Feedback from Students and Industry Partners

Figure 10 shows the reflection of a student upon completion of the AR assignment. Learning is evident as the student is able to reflect on what they had learned from the project, their assessment of what they have done well, and further improvement to the assignment.

Learned	Done Well	Improvement
Learned how to freeze the vuforia screen.	Adding an instruction button for which is hyperlinked into a PDF file where users can follow the instructions when needed.	Adding a white background behind the component image so that it would contrast and not blend in with the machine to make it easier for users to see.
Hyperlink codes so that when image is pressed it brings them to the certain website	Coding/Decorating for user friendly interface	Make the locators auto fixed to the component rather than making the user adjust the camera to fit into the location. Or rather have a more precise locator with the fixed view.
Familiarised myself with the unity hub functions and canvas and more. (Linking variables from c script to the game object in the unity hub).		

Figure 10: Student's reflection on AR Assignment

Module Experience Survey (MES) conducted in both Apr 2021 and Oct 2021 semesters as shown in Figure 11 achieved high student ratings for survey questions on "The module has helped to developed useful skills and knowledge"(and "The module stretches the student's thinking" (5.53 out of 6). This is higher than NP's average rating of 5.15. The overall experience in the module received a high rating of 5.59 out of 6 as compared to NP's average rating of 5.10.

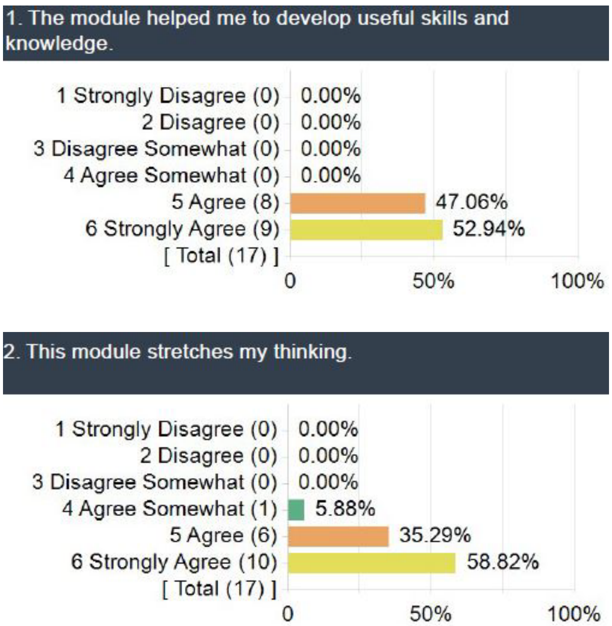

Figure 11: Module Experience Survey (MES) results

Quality students' feedback on the IRP3 has been encouraging. During a Staff Evaluation on Teaching (SET) conducted for the IRP3 module leader, students commented positively on course relevancy and currency in the area of Industrial Internet of Things (IIOT) and Augmented Reality (AR) to real-world industrial applications. Students also remarked that the projects in the IRP3 module were critical in developing their technical skills in emerging technologies and generic skills such as problem-solving, reflective thinking and self-directed learning.

The IRP3 module also received good feedback from the Industry Partner during module moderation that the module content is engaging and keeping up to date with industry practice. The Industry Partner also noted that the module has a good mix of written assignments and projects.

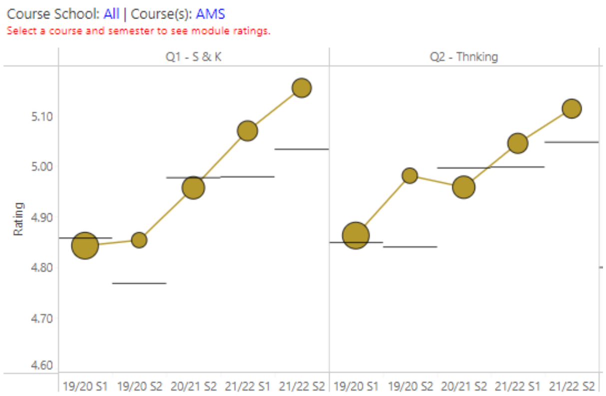

Figure 12: AMS Module Experience Survey (MES) results

Figure 12 shows the AMS course overall MES from Academic Year (AY)2019/2020, Semester 1 onwards. There has been an upward trending in the AMS course MES results since AY2021/2022 Semester 1after the curriculum transformation was carried out for both Year 1 and Year 2 modules. In Apr 2021 and Oct 2021 semesters, the AMS's MES score was above the School of Engineering's average as indicated by the horizonal line for developed useful skills and knowledge, and stretching student's thinking.

The transformed curriculum modules are also ranked consistently high as compared to other pre-transformed modules. Figure 13 shows the ranking of the MES results for the top 4 performing modules for the Oct 2021 semester. 50IRP3 was ranked top in developing skills and knowledge and stretching student's thinking. Other modules in the transformed curriculum such as 41IA and 50IRP4 were also ranked high as compared to the other modules in the semester.

Module-Class Group Ratings for AMS in 21/22 S2

Catalog Nbr..	Q1 - S & K	Q2 - Thnking	Q3 - T & L
50IRP3	5.53	5.53	5.41
50IDSAMS	5.26	5.29	5.35
41IA	5.45	5.36	5.27
50IRP4	5.32	5.18	5.24

Figure 13: AMS Module Experience Survey (MES) results

Conclusions

In conclusion, the curriculum transformation of the AMS was carried out in response to changes in the industry. The curriculum was updated with practices and emerging trends in the industry in its stepped progression design of the curriculum. Emerging technologies such as Industrial Internet of Things (IIoT), Cloud Computing, Data Analysis & Visualisation, Computer Vision and Augmented Reality, Advanced robotics, and Autonomous vehicle is added to the revamped curriculum after the review.

An example of how emerging technologies is implemented into the IRP3 module is presented. The implementation includes real-world scenarios that students would need to research and solve in emerging technologies in AR and IIoT. Students' learning is evident from their report reflections and submission. MES ratings on modules where emerging technology has been incorporated were positive and achieved high score. Qualitative feedback has also been encouraging with good comments from students that they have learned concepts that can be applied in real-world context.

Following the initial success of emerging technologies implementation in IRP3 module in the AMS Year 2 curriculum, Emerging Technologies in Advanced Robotics and Autonomous Vehicle arecurrently been implemented in Year 3 modules. The course team will continue to monitor the implementation and feedback from stakeholders.

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Society 5.0-oriented education in the Metaverse

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Abstract

Incorporating the guidelines of Society 5.0 into educational services, we will objectively estimate and analyze the activity in the learning field as a new evaluation method for discussion-based learning that does not share physical space. We examined the effectiveness of feedback in educational activities through education in the Metaverse. The target learning method is problem-based learning (PBL), the most effective active learning method. Society 5.0 was described by the Cabinet Office of Japan as the vision of a future society that Japan should aim for in the 5th Science and Technology Basic Plan. Society 5.0 is a new society following the hunting society (Society 1.0), agricultural society (Society 2.0), industrial society (Society 3.0), and information society (Society 4.0). In the information society (Society 4.0) so far, knowledge and information are not shared, and there is a problem that cross-disciplinary cooperation is insufficient. The Corona disaster is increasing opportunities to use ICT (information and communication technology) such as telework and remote teaching. In recent years, while new learning environments have been developed in various fields to respond to the accelerating information society, we will present our research on learning environments that utilize Metaverse and VR technology as essential learning tools. Using metaverse VR technology makes it possible to promote learning by answering "given questions" and "asking questions on one's own. In addition to promoting comprehension, the immersive experience stimulates the brain and is expected to improve motivation for learning. This paper introduces the metaverse VR teaching materials (3DCG VR content) we have developed. We will also discuss the effectiveness of the metaverse VR materials and provide some future perspectives on metaverse education. In Society 5.0, a massive amount of information from sensors in physical space will be accumulated in cyberspace. In cyberspace, artificial intelligence (AI) will analyze this big data, and the results will be fed back to humans in physical space in various ways. By utilizing metaverse VR in education, it is possible to synchronize physical space and cyberspace.

Keywords: *Society5.0, Metaverse, Educational activities, Active learning, PBL*

Introduction

Society 5.0 is a human-centered society that balances economic development and the resolution of social issues through a system that integrates cyberspace (virtual space) and physical space (real space). (Cabinet Office., 2022; Cabinet Office, 2015) It is a new society following the hunting society (Society 1.0), agricultural society (Society 2.0), industrial society (Society 3.0), and information society (Society 4.0). Japan's Cabinet Office has presented an image of this society, as shown in Figure 1. Society 5.0 will be realized through systems that highly integrate cyberspace (virtual space) and physical space (real space). For example, in the past information society (Society 4.0), people accessed cloud services (databases) in cyberspace via the Internet to obtain and analyze information and data. The Japanese Cabinet Office explains this as shown in the image in Figure 2. In Society 5.0, a vast amount of information from sensors in physical space will be accumulated in cyberspace. In cyberspace, artificial intelligence (AI) will analyze this big data, and the results will be fed back to people in physical space in various ways. In the information society, value has been created by humans analyzing information. However, in Society 5.0, AI will analyze enormous amounts of big data beyond human capabilities. The results will be fed back to humans through robots and other means, bringing new value to industry and society that was not possible before. This will bring new value to industry and society.

The English name "metaverse" was coined by combining the English words "meta" and "universe. (Park & Kim, 2022; Huang et al., 2021; Hwang et al., 2022; Zhang et al., 2021; Bourlakis et al., 2009; Díaz et al., 2020; Egliston & Carter, 2021; Jeong et al., 2022; Kye et al., 2021; Wiederhold, 2022)) Originally, it was the name of a fictional virtual space service that appeared in the cyberpunk novel "Snow Crash" published by science fiction author Neal Stephenson in 1992. (Stephenson, 1992) However, later, when various virtual space services appeared due to technological evolution, it became a generic name for them and the virtual space itself. The name was later used as a generic term for these

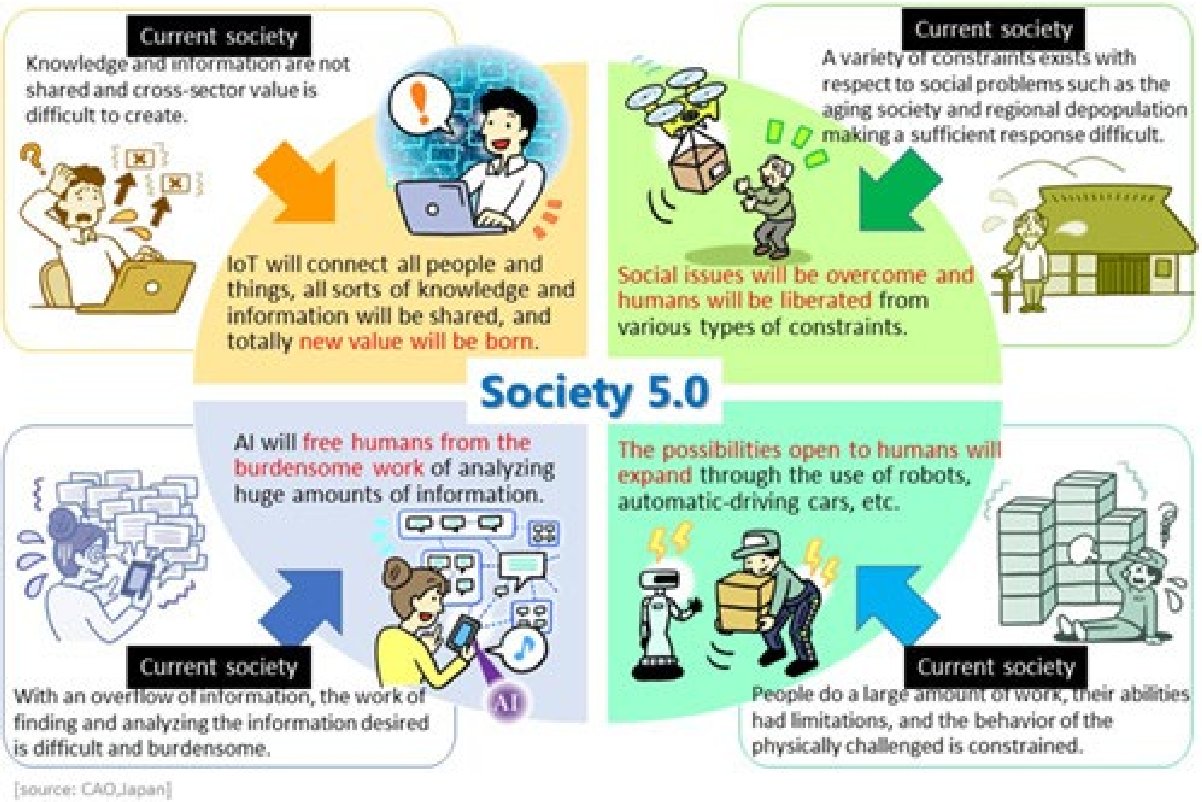

Figure 1. Social reform (innovation) in Society 5.0 will achieve a forward-looking society. (Cabinet Office, 2022.)

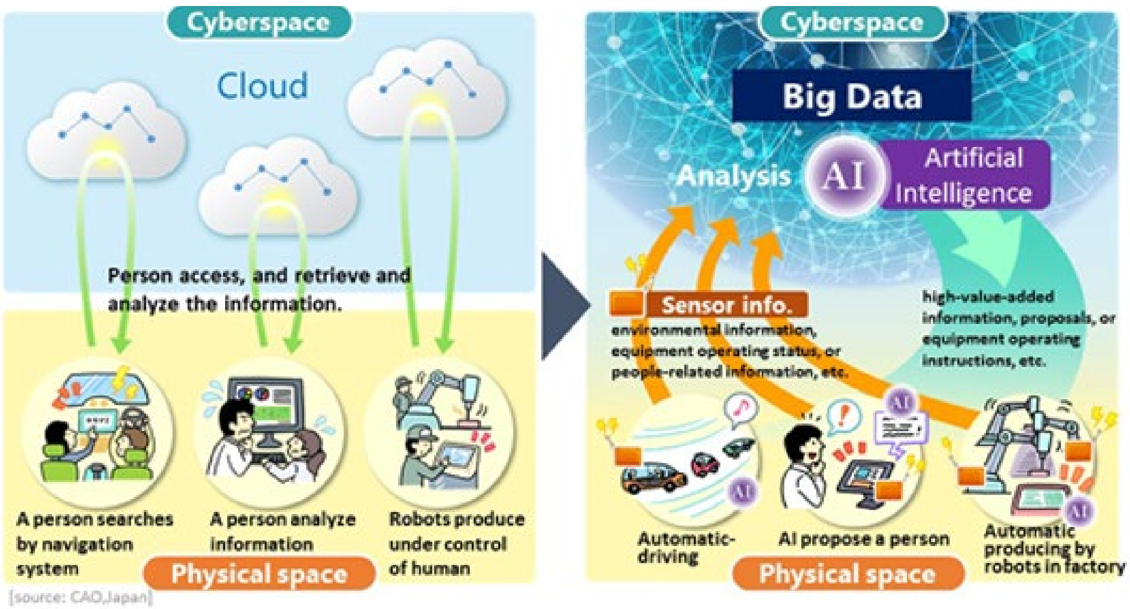

Figure 2. Society 5.0 achieves a high degree of convergence between cyberspace (virtual space) and physical space (real space). (Cabinet Office, 2022.)

services and virtual spaces, mainly in the English-speaking world. Metaverse is a concept that the Internet environment will reach in the future, where users from all over the world will participate in a 3DCG virtual space constructed online as their alter egos, called avatars, and communicate with each other to conduct economic

activities such as shopping and creating and selling products within the service. The avatars are expected to communicate with each other, engage in economic activities such as shopping and the production and sale of products within the service, and live a new life as another "reality.” A metaverse is a three-dimensional virtual space or service constructed in a computer or computer network.

Various definitions of Metaverse have been proposed. However, there is still no unified interpretation. The metaverse commentary "Metaverse Evolution" (Virtual Bishoujyonemu, 2022) defines it as an online virtual space that satisfies the seven requirements of "spatiality," "self-identity," "large-scale simultaneous connectivity," "creativity," "economy," "accessibility," and "immersiveness. Virtual space originally had several names, including WIRED (connected place), VR (virtual reality space), and cyberspace.

Methods

Metaverse technologies are closely related to XR technologies and are inclusive of each other. XR is a general term for technologies that fuse the real world with the virtual world to allow people to perceive things that are not real. Therefore, technologies such as VR (virtual reality), AR (augmented reality), and MR (mixed reality) are all included in XR. The background to the emergence of the term XR is the emergence of technologies that combine VR and AR. For example, if a VR game using a head-mounted display is combined with AR content, it is difficult to draw a boundary as to whether it is VR or AR. This is where the term XR was born.

VR stands for "Virtual Reality," a technology that allows users to experience a virtual world as if it were real through a unique head-mounted display that displays omnidirectional images created by computer graphics and 360-degree cameras. The feature of this technology is that users can enjoy a 360-degree virtual space no matter which direction they turn their eyes. In addition to dedicated VR equipment, VR goggles can be used simply by setting a smartphone on them. Furthermore, technology allows users to control avatars by attaching sensors to their hands and feet and moving their bodies. In recent years, VR technology has been used in projects such as VR meetings in which avatars are displayed in a virtual world, research and utilization of VR campuses and VR offices using similar technology, and even VR training that reproduces work sites in a virtual world.

AR stands for "Augmented Reality," a technology that allows users to experience a virtual world superimposed on the real world. Unlike VR, the real world is visualized, and information from the virtual world is superimposed on top of it. Likewise, unlike VR, there is an image of the natural world, and the information of the virtual world is superimposed on it.

MR stands for "Mixed Reality," a technology that fuses the real world with the virtual world, which may sound similar to AR. However, while AR "augments" reality by displaying information from the virtual world in the real world, MR "combines" the real world with the virtual world more closely. MR, on the other hand, more closely "composites" the real and virtual worlds. For example, a typical example of MR is displaying 3D images in the real world. This enables people wearing smart glasses to experience a life-size dinosaur moving around in front of them as if it had appeared in the real world.

In applying such metaverse technology to education, we focus on its relevance to PBL as a form of instruction. With metaverse VR technology, it is possible to bring an unreal space before our eyes and immerse the viewer in it with overwhelming realism. VR can be a tool for engaging learners and deepening their understanding in educational settings.

VR can express things in a far more subtle way than models. For example, actions that can only be performed with VR, such as the operation of releasing a plate from the earth, are possible. In addition, the ability to show students more detailed and realistic images is a great educational tool. Learners feel more immersed as if they are in the space than showing pictures or videos. Since their viewpoint is not restricted, they are more interested and participate in the activities voluntarily. Active learning, or the active participation of learners in the classroom, also impacts their learning outcomes.

Results and Discussion

In this study, an educational environment was developed using Unity, as shown in Figures 3 and 4. Unity is a development engine system provided by Unity Technologies. Unity is not only an excellent UI but also has a rich library and collection of materials, making it easy to obtain high-quality materials and create graphical tools, even if you start developing on your own. Unity is also suitable for AR/VR development, where demand rapidly increases due to the recent increase in compatible apps and peripherals. Unity is cross-platform, so it can be used on iOS, Android, OSX, Windows, PlayStation4, PlayStation2, PlayStation3, PlayStation4, PlayStation5, and Xbox. This makes it suitable for creating applications that interoperate with each other. Because of this feature, there are cases where people dare to choose Unity when developing tools to be released on multiple platforms, such as schedulers, calendars, and chat tools. Also, because of its strength in 3D, Unity is used for industrial and architectural design tools that require 3D models.

C# is the current development language for Unity. Previously, there were three languages to choose from C#, JavaScript, and Boo, but with JavaScript and Boo being discontinued, the focus of development has already shifted to C#. In the latest Unity, the editor has been changed so that you cannot select a language other than C# for new projects. When developing a system in Unity, you can create a simple system without writing any code because you can do some things in the editor. However,

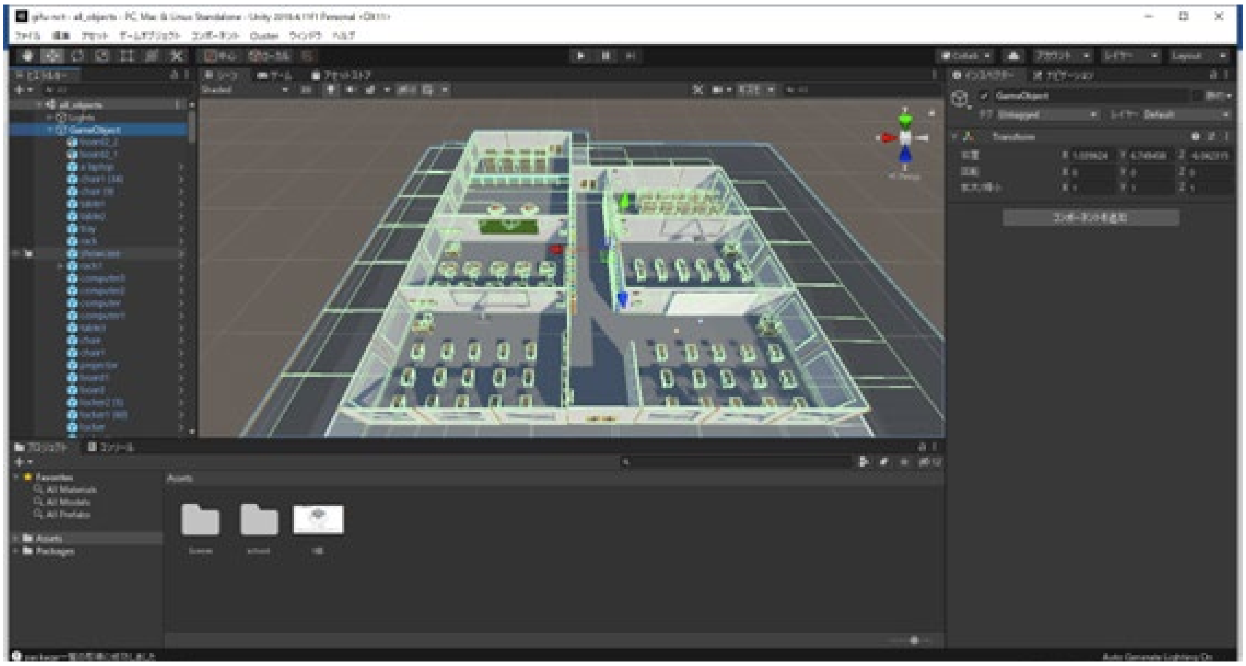

Figure 3. Using unity, we developed a metaverse learning environment with multiple classrooms.

Figure 4. The student can manipulate his avatar to move between classrooms for different studies in the created metaverse.

Figure 5. Here is a snshot of the avatar entering a classroom in the metaverse.

if you want solid development, you will need some knowledge of C#.

The system we have developed has been used by students at our college and has been very well received. (Figure. 5 and 6.)

The system developed in this research was a VR content by creating 3DCG and designed in a virtual space. Since the virtual space is created with 3DCG, it is possible to reproduce environments that are difficult to capture in real life and situations that do not exist. In addition, the contents allow users to learn by moving their avatars through game-like operations. Experiences such as grabbing something on the VR screen and moving it in one's hand or moving one's body back and forth, which are complex with live-action filming, are possible with 3DCG VR content. On the other hand, the workload tends to be higher than for simple 360-degree videos because, unlike shooting live-action, 3DCG production and system construction are required.

Figure 6. Here is a snapshot of an avatar manipulating the VR materials created, in the

Conclusions

This paper presents the results of our work on Society 5.0-oriented education in the Metaverse. As mentioned, development in the Metaverse VR requires a heavy workload for creation, but the materials created are very effective and highly evaluated. In addition, the advantages of introducing metaverse VR into various types of education include the following points.

- ✓ By converting educational content into metaverse VR content, students can practice as often as they wish.
- ✓ The actions taken in the metaverse VR space can be converted into data, and the contents can be reviewed.
- ✓ It is possible to experience education in dangerous or emergencies that are difficult to reproduce in a metaverse VR space.
- ✓ Uniform training can be provided without being influenced by the quality of the instructor's or senior staff's instruction.
- ✓ Reduction of transportation and equipment costs required for education and training.

While we have introduced the use of metaverse VR for education, there are cases where technologies such as AR and MR are more compatible depending on the educational content. For example, MR glasses, a glasses-shaped digital device, can be used to display information through transparent glasses. In addition, AR and MR technologies can be used for education by displaying digital data in the real world rather than in a virtual space, such as VR.

In addition to programming VR content, as in the case of Metaverse VR, it is possible to create VR content using a 360-degree camera to take live-action photographs and create VR content. Since live-action photography is used, it is possible to develop realistic VR content at a low cost as long as the shooting environment is prepared. On the other hand, it is difficult to shoot dangerous or emergencies with live-action filming, and there are restrictions on what can be converted into VR content. In addition, since the live-action video is only a video shot, it is not possible to grab and move objects on the VR screen or move one's body back and forth or left and right.

Japan's Cabinet Office will lead the world in realizing "Society 5.0," a human-centered society in which everyone can lead a comfortable, vibrant, and high-quality life by incorporating advanced technologies into all industries and social life and creating new value from innovation. This is a society where every person plays a central role and is by no means a future dominated and monitored by AI and robots. It will also lead to solutions to various issues not only in Japan but around the world and to the achievement of the United Nations Sustainable Development Goals (SDGs).

This paper is a report on efforts made in education in the Metaverse in line with Society 5.0 and is highly important. We will continue to promote research on education in the Metaverse.

Acknowledgments

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DEVELOPMENT OF VIRTUAL REALITY VIDEOS FOR TEACHING ENGINEERING EXPERIMENTS

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Abstract

The number of young and/or skilled engineers is currently declining in the Japanese construction industry. The main reason for this is a combination of declining birth rate and skilled engineers retiring. As a set of skills that benefits greatly from mentorship, civil engineering is being taught to the next generation of young engineers by skilled engineers in many institutions. Here at the National College of Technology (KOSEN), Fukushima College, we also provide a technical education through attending classroom lectures and completing practical experiments. However, there are several problems that instructors face regarding these experiments. First, experiments are more labor intensive than classroom lectures, and second, one instructor must attend to many students at once. Furthermore, students cannot repeat the experiment for review purposes. To solve these problems, we developed a virtual reality (VR) video that students can use for both experiment preparation and review. An educational experiment was captured with a 360-degree camera, and the video was edited to clearly show the scenes of interest. After that, the edited video was projected onto a head-mounted display. In the VR video, the instructor conducting the experiment can be seen in 3D, giving the viewer the illusion of being present in the room and participating in the experiment. In addition, students can watch the experimental process, material behavior, and measurement results from various angles. In this study, we examined whether this VR video would resemble a traditional face-to-face experiment session. We then examined whether this VR video represents the class material well, whether it is easy for students to use, and whether it is effective for learning.

Keywords: *VR video, experiment education, 360-degree camera, Development of educational materials, HMD*

Introduction

In the Japanese construction industry, there is a shortage of skilled engineers due to the declining birth rate and aging population, and there is a pressing need to ensure younger engineers learn the necessary skills of their profession, particularly those that require a degree of practical knowledge. To this end, the National Institute of Technology (KOSEN), Fukushima College, which aims to nurture engineers, is developing highly advanced practical education methods. In the last few years, the spread of COVID-19 often forced us to conduct classes remotely, and there were many periods when face-to-face classes could not be held. It is more necessary than ever before to develop teaching materials comparable to face-to-face education for students and engineers.

In recent years, virtual reality has been increasingly used in the field of education. The purpose of this study is to use virtual reality to aid in visual learning, repetitive memorization, and achieving a sense of craftsmanship without feeling that the objective is to study, regardless of time, place, or individual learning speed.

This study uses an example experiment on concrete materials. In the experiment, the student is tasked with determining the properties of aggregate and cement, which still often relies on empirical "intuition" at an actual construction site. A 360-degree video was produced of the experiment for projection into VR, and the VR video was then compared to a traditional face-to-face class to see if the texture, moisture state, and ease of handling of the concrete materials were accurately represented.

Materials and Methods

As summarized in Table 1, the experiment in this study covers fine aggregate density and water absorption tests, a concrete slump test, an air content test and test piece preparation, and a compressive strength test of concrete. These contents make up part of the third year engineering curriculum at the National Institute of Technology (KOSEN), Fukushima College.

Table 1. Experiment contents

No.	Items and Contents
Experiment (1)	**Fine aggregate density and percentage absorption test** ・Preparation of samples (sand) in a saturated surface dry condition ・Density test ・Water absorption test
Experiment (2)	**Fresh properties of concrete** ・Material weighing (cement, sand, stone, admixture, water) ・Concrete mixing by electric mixer ・Slump test ・Air content test ・Production of test pieces using a simple mold
Experiment (3)	**Hardened properties of concrete** ・Polishing the test piece produced in Experiment (2) ・Measurement of dimensions and mass of the test piece produced in Experiment (2) ・Compressive strength test of the test piece produced in Experiment (2)

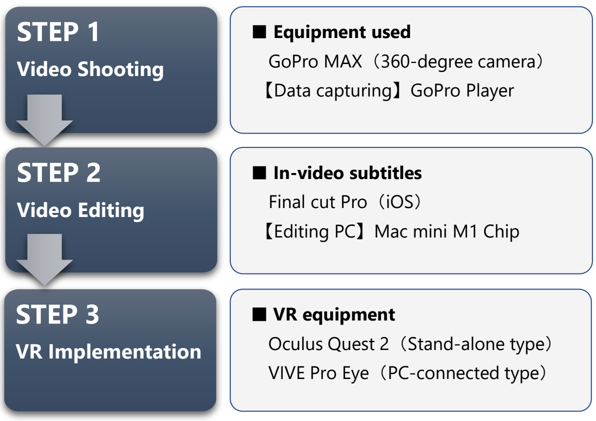

Figure 1. Work procedure and equipment used

Figure 2. Camera and HMD (Head Mounted Display)

Figure 1 shows the workflow and Figure 2 shows the equipment used. The work process consists mainly of video shooting, video editing, and VR implementation. For video shooting, a 360-degree camera was used to capture video of the actual face-to- face class, focusing on the texture of each material, which is difficult to express in 2D videos, as well as the amount of water content due to wetness, the consistency and ease of handling when mixing the concrete, and the degree of fluidity. The camera was moved as necessary, keeping in mind the content of the class, the details of the experimental processes, the angles and viewpoints the viewer may want to see, the instructor's standing position, and other factors. When switching to fixed-point or hand-held shooting, we attempted to shoot in such a way that the immersive and realistic sensation that is characteristic of VR experiences could be fully obtained.

After shooting, subtitles and effects to assist learning were added using video editing software that supports 360-degree videos. Finally, the produced 360-degree video was projected onto a head-mounted display (HMD). Two types of head-mounted displays were used: a simple and inexpensive stand-alone device, and a high-performance PC-connected device mainly for developers.

Hardware environment

In general, development using the aforementioned equipment requires a high-performance PC environment capable of installation, data reading, editing, writing, and saving. The PC specifications used in the present study are listed in Table 2. Note that in order to improve work efficiency, it is important to ensure a development environment exceeding the recommended PC specifications according to the equipment used, while also considering the content being developed. The 360-degree video used in this study consumes a large amount of data space of approximately 30 GB for a video about one hour long shot in 4K.

Results and Discussion

Figure 3 shows still images of a portion of the produced VR video. The upper photo shows the instructor explaining the experimental method to the students. Shown in the middle photo is a view of the fresh concrete mixed to produce the test piece as it is being pressed into the mold. Finally, the lower photo shows a compressive strength test of the concrete using the test piece produced in the previous experiment. Subtitles in the video were added to explain the test method, guide the viewer's gaze, and provide a visual learning effect in situations where the viewer senses changes in the ease of handling materials due to differences in moisture conditions. The other parts of the experiment were also edited using the same method and implemented in VR.

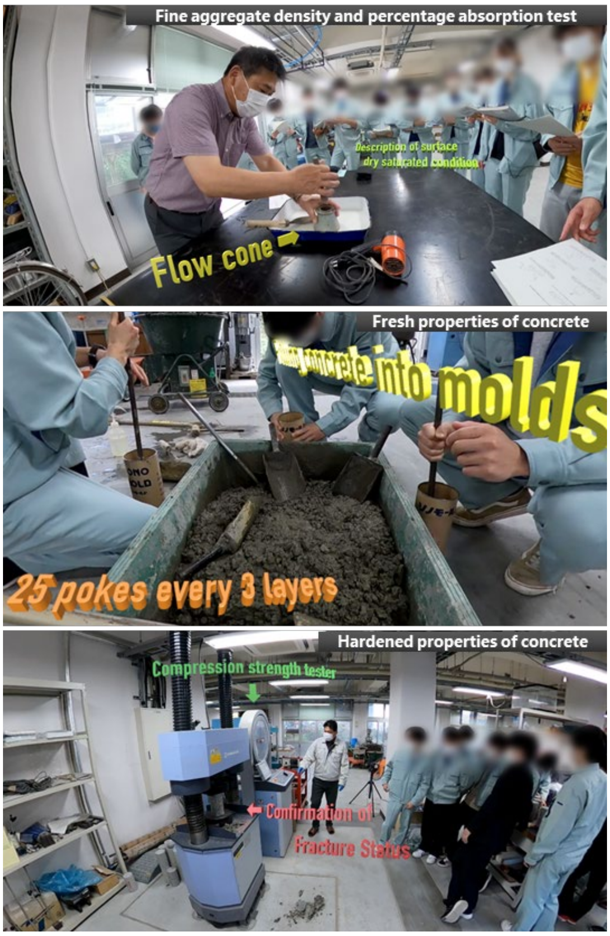

Figure 3. Still images of the produced VR video showing educational subtitles

Figure 4 shows a faculty member watching the implemented VR video. The sense of immersion during the VR experience, the feeling of wearing and weight of the HMD, and the sense of distance or angle to the video greatly depend on the individual, but these factors are considered important in the video's evaluation. Therefore, we conducted a VR demo experience for some engineering faculty members, and then used a questionnaire to obtain feedback.

Figure 4. The VR demo experience

Table 3 summarizes the list of questionnaire items administered to those who experienced the VR demo. The results of the questionnaire showed that a high sense of immersion and realism, which are characteristic of VR experiences, were generally obtained. A 360-degree video differs from a 3DCG space, where the viewpoint can be moved freely within the VR space, because in 360-degree videos, the position where the viewers themselves stand is determined by the position of the camera that shot the video, and is therefore fixed. Nonetheless, one of the opinions we received from the questionnaire was that students could watch the videos without getting bored

Table 2. Data capacity and PC specifications

360-degree video data	Shooting 60-90 min : 30-50 GB	
Video Editing	Mac mini (Apple Desktop PC)	
	OS	MacOS
	CPU/GPU	Apple M1 chip
	RAM	16GB
	SSD	1TB SSD
PC ・Data capture ・VR Implementation	raytrek R5 (Build To Order laptop)	
	OS	Windows 10 Enterprise
	CPU	intel Core i7-10875H
	GPU	NVIDIA GeForce RTX 2060 6GB
	RAM	32GB DDR4 SO-DIMM
	SSD	1TB NVMe SSD

Table 3. Questionnaire items for experience viewers

Questionnaire items	Answer format
Respondent information ・Gender ・Affiliation ・Field of study ・VR model experienced	**Choice**
Previous VR experiences ・Content of experience ・VR model used	**Multiple choice**
Possession of own VR device (HMD)	**Choice**
Experience Satisfaction ・Immersive ・Realistic ・Fit feeling ・Video distance ・Video resolution ・Video angles ・Subtitles information ・Video-to-video effects ・Learning time ・VR sickness	**Choice (5-point scale)**
Comparison with face-to-face classes (Pros and cons) ・Teaching effectiveness ・Class reproducibility ・Viewpoint flexibility ・Time constraints ・Location constraints ・Visual learning ・Craftsmanship ・Object texture ・Entertaining elements ・Reduction in the number of required teachers	**Multiple choice**
・Other comments	**Free answer**
Applicability ・Alternative to face-to-face classes ・Alternative to follow-up experiments ・Student preparation/review ・Remote teaching ・Trial enrollment ・Graduation studies ・Improving faculty skills ・Entertaining elements ・Reduction in the number of required teachers	**Multiple choice**
・Other comments	**Free answer**
New topics of interest to experience	**Multiple choice**
Overall satisfaction level	**10-point scale**

and with little sense of "learning" (as in the case with traditional face-to-face teaching or 2D instructional videos), which was considered a positive aspect that could foster interest. Students often tend to lose their ability to concentrate on understanding the content over time, both during the actual face-to-face class and while viewing 2D videos. If the VR video keeps the viewer focused, the learning effect is expected to improve. In addition, the ability to repeatedly watch a scene of interest is more effective for preparation and review than a one-time face-to-face class.

On the other hand, in a VR video, in addition to the movement of the viewpoint of the viewer, the viewpoint also changes based on the movement of the camera itself, for example, movements during hand-held shooting, or changes of position during fixed-point shooting. Therefore, the discrepancy in perception between the brain and the physical body tends to cause motion sickness. Additionally, for the topic of "Craftsmanship" in the questionnaire, the results showed that contents that enable a more detailed understanding of practical work situations are necessary.

In the future, based on the survey opinions obtained after the VR demo experience, we will enhance the contents, especially to reduce motion sickness and to improve the sense of craftsmanship. For this purpose, new shooting and editing will be conducted to modify the VR video produced in this study. In addition, we will ask students who have actually taken face-to-face classes to experience the modified VR videos, and we will conduct a questionnaire survey for more detailed comparison and evaluation.

Conclusions

In this study, a concrete experiment class was shot using a 360-degree camera and the VR video was projected onto a HMD. A demonstration experience of the VR video was conducted and compared to an actual face-to-face class based on the results of a questionnaire. The following findings were obtained.

・In terms of experience satisfaction, the sense of immersion and realism was high using the VR video.

・Viewers can immerse themselves in the VR video without being aware that they are learning.

・VR videos can be watched over and over again, which is expected to be effective for preparation and review of materials.

・Depending on how the video is shot, there is a possibility of feeling motion sickness.

・Technical content to foster a sense of craftsmanship needs to be enhanced in the future.

・For a more detailed evaluation, it is necessary to conduct VR demonstration experiences for more students and faculty in the future, and collect and analyze survey data.

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A CLASS TO DISCUSS SOLUTION IN SOCIAL ISSUES AS ENGINEERS

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Abstract

Our university has a class for graduate course "Advanced Lecture on Social Innovation" to learn facilitation skills of workshop to create their solutions and make consensus building to overcome the issues. The lecture includes studies of knowledge and skills on logical thinking, workshop and facilitation. The students can develop their workshop and facilitation capabilities through several workshop activities based on their knowledge to be learned in the subject. In addition, students in the present class joined mainly from Department of Mechanical Engineering and Department of Bioengineering for making interdisciplinary interaction in the workshop activity. Almost of our students have the first experience to make workshops under the serious rules. Generally, Japanese students have less experiences on discussion, criticism, and logical thinking in their educational history. The teaching staffs encourages thinking and discussing freely with the teammates because Japanese communities has high peer pressure even in the student community of the university. The teaching staffs made the system to evaluate performance of students attended in the class with two different rubrics for workshop teammates and self-evaluation as well as evaluation from the teaching staffs.

Keywords: *Social Issues, Workshop, Brain storming, Facilitation, Logical Thinking, Rubrics*

Introduction

Traditionally, many classes in engineering courses in Japanese universities are established to teach science and engineering knowledges, skills and technology trends. Practical classes on engineering experiments and excises to learn engineering skills are also regarded to be very important to establish engineering sense of students as well as laboratory work. The education style was criticized from Japanese industries to make students passive in 2000's or 2010's. As a result, many Japanese universities and technical colleges (so-call Kosen) had introduced problem-based or project-based learning (PBL) to make students think and discuss themselves and to develop their creativity. Additionally, PBL can enhance communication ability and leadership/followership of students by discussion between students to establish any solution for the problem or through the project. Yamaguchi (2017) investigated the trend of PBL in Japanese universities. Kosen introduced actively PBLs in their curriculum from early 2000's. National Institute of Technology (NIT), which is the head quarter of national Kosens, has introduced the Model Core Curriculum (MMC), which is the common curriculum in each college of NIT. The guideline of MMC included of PBL for establishing interdisciplinary competency for engineer, NIT (2017). The prototype of MMC has been built in 2012.

Difficulties of PBL for teaching staffs as classes of universities and technical collages are as follows: 1) setting the purpose of lectures, 2) proper scoring method, 3) capability for PBL of teaching staffs and so on. In particular, the authors sometimes found the PBL classes with just evaluation "how much interest the class have in the students". Making the score is a big problem to understand the evaluation for both students and teaching staffs.

Leadership is very important competency for engineers. In particular, Our university, Nagaoka University of Technology (NUT) aims to produce leading engineers equipped with practical and creative abilities who can contribute to the prosperity of humankind. We need any educational system to make leadership for engineers, who have important roles to promote science and technology innovation and responsibility for social activities as members of community. They must face their own social issues and create any solution for the issues.

As one of education programs for leadership, our university has a subject in the graduate course "Advanced Lecture on Social Innovation" to learn facilitation skills of workshop to create their solutions and make consensus building to overcome the issues. In this report, the design on the curriculum and evaluation system of the subject are described as well as the actual practice of the classes for four years.

Curriculum Design

The purpose of the subject "Advanced Lecture on Social Innovation" is to learn facilitation skills of workshop to create their solutions and make consensus building to overcome the social issues. Many graduates of NUT work as engineers in industrial companies. In their daily work, they have to contribute to solve their own issues with their community. In particular, they have to be leaders to dissolve the issues. As Japan is in an aging society now, our graduates lived in the suburban or local area may be the unique young generation in their daily life community. They need to take on the leadership of the argument to develop ideas of the solution and to make agreement in their community. This subject consists of three parts: lectures on workshop and facilitation knowledge and skills, excise of workshop and case-studies on social innovation. Table 1 shows typical schedule of this subject.

Table 1 Typical Schedule of Advanced Lecture on Social Innovation

day	Contents
1	Guidance
2	Workshop I: How Increase Marriage Rate of 30's
3	Workshop II: How Increase Marriage Rate of 30's by using Technology
4	Lecture I: Fundamentals of Workshop: Icebreaking,
5	Workshop III: How Increase Marriage Rate of 30's by using Technology
6	Lecture II: Listen Skills, Communication and Consensus Building
7	Case Study I Homework: Literature Survey of Workshop IV
8	Workshop IV: Share of Results of Literature Survey and Workshop
9	Lecture III: Graphic Facilitation and Logical Thinking,
10	Case Study II
11	Case Study III
12	Workshop V-1: Setting of Topic for Workshop
13	Workshop V-2: Workshop
14	Workshop V-3: Presentation Preparation, Presentation and Evaluation
15	Review Meeting

In the present subject, the order from experience to lecture, then experience is adopted to understand deeply the contents of the lecture. The students attending the present subject can understand difference of workshop with and without facilitation and workshop skills step by step. In workshop activities, the teaching staffs gives comments how students use any skills given in the previous lectures, as well as quality of their workshop and reality of the solutions. The students can understand the workshop and facilitation skills step by step and how much can they use in real workshop.

The students can know real activities of social innovation from the case studies. The speakers of the case studies are the teaching staffs and some innovators working in NPO or social venture companies. They are just doing now their challenges for particular social issues. The students can understand meaning of social issues and how the speakers struggle their own issues. We believe that their real efforts may affect the vitality of the students as well as motivation for their own social innovation.

In the part of lecture on workshop and facilitation knowledge and skills, we introduce lectures on logical thinking, workshop skills and facilitation skills. The lectures logical thinking includes visual thinking technique as graphic facilitation. Skills for listening are also introduced. In workshop skills, the famous rules of brain storming are introduced as follows:

1. Focus on quantity, not quality,
2. No criticism,
3. Encourage wild ideas, and
4. Combine and improve ideas

The 1st and 3rd rules seem to be difficult for many students in our university. This tendency is easily expected from general understanding of Japanese students to hate failures and to try to find the correct answer. As well, they have been requested to be "Not Wild" in their education history by now. Making atmosphere of the class to accept wild and wrong ideas and discussion is very important for teaching staffs for this class.

Evaluation of the students is a big problem of this kind of lecture style. In the present subject, combination of rubric evaluation of students themselves and mutual rubric evaluation of peer students, as well as evaluation from the teaching staffs. Figure 1 show the rubric sheet of self-evaluation and peer-review in the workshop. The minute paper is also used after each class to evaluate performance of students. As the teaching staffs observed each workshop and final presentation, the evaluation by teaching staffs is included additionally in the score of the students attending the present subject.

The present subject is open for graduate students of both Department of Mechanical Engineering and the Department of Bioengineering. The topics for workshop examples should be set as both department students have interests and have similar scientific knowledge.

A minor problem of the present subject is language to conduct the workshop. Graduate students in the master course in our university includes around 10% non-Japanese nationality students, who cannot speak Japanese well. As the present subject is not a language class, any automatic translation in smart phones is available. Many Japanese students take an attitude to hear just English talk of non-Japanese students and to hesitate to discuss with them. The teaching staffs encourages Japanese students to discuss with non-Japanese students with any automatic translation and visual communication.

ソーシャルイノベーション特論ルーブリック評価②　　（　　）班　学籍番号（　　　　）氏名（　　　　）

	キャップストーン(4)	マイルストーン(3)	マイルストーン(2)	ベンチマーク(1)
Q1Metacognition and listening	同じ班の他の人の意見を聞いて、その内容を理解するだけでなく、その人がなぜそのような発言をしたかをその人の内面の考えを想像しながら意見を聴くことができた。 Listening to the opinions of other people in the same group, not only understanding the contents but also I could listen to opinions why that person made such remarks imagining the inner thought of that person .	同じ班の人の意見を聞いて、その内容を理解することができた。自分とその人が話していることを客観的にみる努力をしながら聴いたので、ある程度相手の気持ちを想像しながら意見を聞くことができたが、議論が白熱すると自分の意見に集中してしまった。 I was able to understand the contents of listening to the opinions of people from the same group. I made an effort to objectively grasp the story of a person, so I could imagine the feelings of the partner to some extent, but when the discussion glows it concentrated on my opinion.	同じ班の人の意見を聞いて理解することはできた。WSの議論を行いながら、自分の意見を出すことに追われ、他の人が出した意見の真意を考える余裕はなかった。あるいは、真意を想像したが、それが正しいかどうか自信がない。 I was able to understand by listening to the opinions of people from the same group. While discussing WS, I was absorbed in putting my own opinion and I could not afford to think about the real intention of others' opinions. Or I imagined the real intention of that person, I'm not sure if that is correct.	同じ班の人の発言は理解することができたが、その意見に対し、自らの意見をうまく伝えることができなかったと感じた。あるいは、なぜそのような発言をするのか全く理解できない班員の人がいた。 I could understand the remarks of people in the same group, but I could not convey my opinion well to that opinion. Or, there was a member of the group who can not understand why he makes such remarks.
Q2Facilitation techniques, consensus building	•ファシリテーターとして班員の意見を促進し、非常に活発な議論を行うことができた。マイナスな発言をしたり、ルールに反した発言をした人をうまくコントロールし、最終的に班員の合意形成を導くことができた。 · As a facilitator, I was able to promote the opinions of the members and make very active discussions. I successfully controlled the person who makes negative remarks and those who speaks contrary to the rules and eventually was able to guide the formation of consensus among the members. •班員として、議論が活発になるよう積極的に発言をした。一方で、班員の話を聞きポジティブに受け止めながら、意見をさらに発展させ、最後はみんなが納得いく結論を得た。 As a member, I actively made remarks so that the discussion will be active. Meanwhile, I listened to the story of other group members positively and accepted positive opinions, further finally got the conclusion that everyone convinced.	•ファシリテーターとして班員の意見を出すことはある程度できたので、WSの議論は活発だった。しかし、ルールに反した発言をする人もなく、班員は熱心に議論をしてくれたので、WSがうまくいったのは、自分の力ではないような気がする。 · Since I was able to give the members' opinions as a facilitator, the discussion of WS was active. However, there was nobody who made remarks contrary to the rules, and the group members enthusiastically discussed, so it seems that WS did not work well for himself. •皆の意見が盛り上がり、自分が積極的に意見を出さなくても良い話し合いができたと感じた。課題の解決策についても様々な意見が出て議論を深めることができた。· The discussion of the group was exciting and I felt that I could talk well without having to positively express my opinion. Various opinions were also raised about the solution to the problem, and the discussion was deepened.	•ファシリテーターとして班員の意見をうまく引き出すことができたが、途中でルールに反した話をする人の言動をうまく制御できなかった。 · I was able to successfully draw out the opinions of the members as a facilitator. However, I could not control the behavior of those who talked against the rules well. •班員として意見を出すことができた。たくさんの意見がでて、それを発展、結合させていったが、最後は特定の意見が前面にでてしまい、他の人はあまり意見を言うことができなかった。 · I was able to express my opinion as a member. Many opinions came and developed and combined it, but at the end there was a specific opinion in the foreground, others were unable to express much opinion.	•ファシリテーターとして班員の意見だしをしようとしたが、議論が盛り上がらず、意見を出させるのに苦労してしまった。 · As a facilitator, I tried to make an opinion of members, but the discussion did not get excited and I had a hard time making opinions. •班員としてあまり十分な意見だしをすることができず、議論が不十分だと感じた。 · I felt the discussion was inadequate because I could not give a sufficient opinion as a member.
Q3Innovative ideas leading to problem solving	課題に対して、過去にないような新しい発想や着想を得て、イノベーティブな解決方法を提案できた。たくさんの人の意見を聞きながら、話し合う過程で良い議論ができたため、このような素晴らしい着想に至れた。 In response to the problem, I got new ideas and ideas that are not in the past, and could propose innovative solutions. While listening to the opinions of many people, good arguments were made in the process of discussion, which led to such a wonderful idea.	課題に対して、新しい切り口から対策を考えることに努力することができた。みんなでいろんな意見をだし、それを発展させたり、結合させる努力をしてみた。ただし、みんなで話し合った事で斬新なアイディアが生まれたわけではない気がする。 I was able to make efforts to think about measures from a new way to the task. Everyone made various opinions, I tried my efforts to develop and combine it. However, it seems that it was not created a novel idea by talking with everyone.	課題に対して新しい切り口から考えるように努力をしたが、うまいアイディアの発展や結合ができなかった。最終的な結論は、奇をてらった内容に落ち着いたが、実現性が低く、課題に対する適切な解決策とは言えない気がする。Efforts were made to think from the new section towards the task, but we could not develop or combine a good idea. Although the final conclusion was a novel proposal, it is not feasible and it seems that it can not be said to be an appropriate solution to the problem.	課題に対し、新しい切り口から考えることがうまくできなかった。アイディアは出したものの、どこかできいたような内容で、ありきたりな解決策になってしまった。 I could not successfully think about the problem from a new perspective. Although I gave an idea, it became a common solution with contents that I could do anywhere.

My role（　　　　）	Q1	Q2	Q3
My evaluation			
name（　　　）Evaluation of members			
name（　　　）Evaluation of members			
name（　　　）Evaluation of members			
name（　　　）Evaluation of members			
name（　　　）Evaluation of members			
name（　　　）Evaluation of members			
name（　　　）Evaluation of members			

Figure 1 Example of a Rubric sheet for self-evaluation and peer-evaluation

Practice of Actual Classes

The present subject has started from 2018 as an elective subject in the master course program in both Departments of Mechanical Engineering and Bioengineering. Capacity of students is limited by thirty persons to keep quality of workshop and presentation. However approximately twenty students including two or three non-Japanese students have joined into the class. Currently four faculty staffs join the subject.

Japanese students do not have less experience to conduct workshop activities in their education history. In order to make good discussion in the present class, making good atmosphere for discussion is very important. The teaching staffs mention often "no problem for making failure and wild ideas". As facilitation skills, importance of making good atmosphere is introduced. At Day 4, students attending in this class have two workshops and icebreaking and result in establishing good atmosphere. Students can understand the importance of making the atmosphere also from their experience.

Figure 2 shows views of a class on workshop activity and speech on the result of the workshop. A group of workshop consists of 4 to 6 students. After the 1st lecture of the workshop skill, the agenda sheet is provided into each workshop group. Figure 3 shows the agenda sheet. The students begin the workshop activity based on the agenda.

Many students contribute to the workshops and discussion in the class with high concentration. Their evaluation for the class is also very high compared with other classes. They seem to have high achievements after their workshop activities. The authors heard that some students evaluate one of the best classes in the university. In fact, the score on the question "do you feel good to join the current class?" in the class evaluation of students has 3.6/4.0 in the average. The students attending the present class were satisfied for the present subject. However, some students scored the lowest point "1" for the present subject. In free description, comments on complaints to negative criticization for their ideas were observed. These comments were evidence that the students attended the class seriously.

目的 *Theme*			
目標 *Goal*		(1) (2)	
役割分担 *Role*		Facilitator：（　　　）　Speech：（　　　） Recorder：（　　　）　（　　　） Timekeeper：（　　　）　（　　　）	
時間		内容	確認
進行	5分	①皆でアイスブレーク（実は…自己紹介） Icebreaking	
	5分	②話し合いの役割決定 Roles	
		③話し合いのルール確認（必要に応じて追加） Rule	
		④話し合いの目的と目標を皆で確認 Target	
	10分	⑤ブレスト（各自で書きだす）3分 Brainstorming	
		⑥一人一枚ずつ発表していく 7分 Idea Presentation	
	5分	⑦整理・順位付け（一人5票）・まとめ Summarizing	
	15分	⑧結果発表（4班×3分） Speech	
	5分	⑨話し合いの振り返り・講評 Reviewing	
計45分			

Figure 3 A workshop Agenda sheet

Evaluation of the score of students shows interesting results. Figure 3 shows an example of rubric scores in the class. The score means summation of three workshops. Scores of self-evaluation are scattered widely from 22 to 32, but these of peer-evaluation are ranged narrowly in high points from 29 to 32. Japanese students may be severe in self-evaluation but easy in peer-evaluation. Female students have tendency to make self-evaluation with low points. The teaching staffs evaluated that their female students showed very similar contribution in their workshop activities with other male students attending in the same workshop groups. The results in self-evaluation of female students are just caused by poor self-esteem in Japanese females. Okada et al. (2015) reported a meta-analysis of gender differences in self-esteem in Japanese. Their analysis said indicating that males scored slightly higher in self-esteem than females. In future, the difference of the scores in self- and peer-evaluation should be open to each student to know how peer evaluates and how different from their self-evaluation to reduce in the tendency of poor self-esteem in Japanese females.

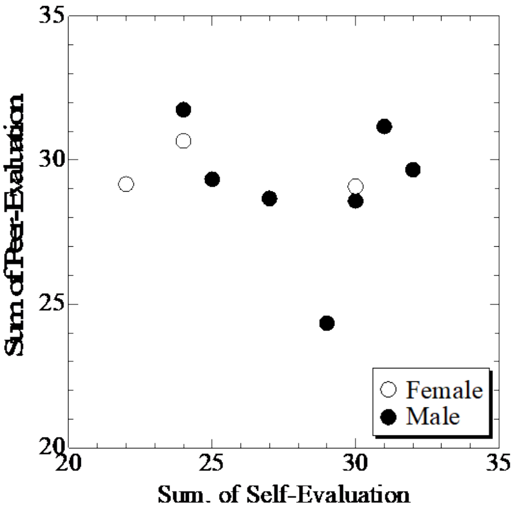

Figure 3 An example of scores on the workshop activity.

Future Improvements

There are some problems and issues to be improved in the present subject. The most important point to be improved is to supply "reality" for social innovation. Many students chose the topics for social issues for the final workshop by net surfing or by TV programs, such as "declining birthrate and aging population in Japan" and "Vacant houses in depopulated areas of Japan". However, the students do not have serious reality. Sight visiting of students to watch the reality of such social issues should be done, but not yet because of poor budget and less vacancy of students. Out graduate course students are very busy for their lab work for their master thesis.

Enhancement of diversity of attendees should be improved. The students attending to the class are mainly these of the dept. of mechanical engineering and bioengineering, but just only early 20's in an engineering school. The students must know how diversity in real society is huge.

The authors hope the present subject is open in other departments even for other universities if possible. Faculty development to conduct this subject in other departments is also very important. For four years, three other professors joined the class to experience new style of lecture.

Conclusions

The subject in the graduate course "Advanced Lecture on Social Innovation" to learn facilitation skills of workshop to create their solutions and make consensus building to overcome the issues is introduced in this report. The design on the curriculum and evaluation system of the class are described as well as the actual practice for four years. In the present subject, the cyclic order from experience to lecture then experience is adopted to understand deeply the contents of the lecture. In the scoring system, mutual rubric evaluation consisting of self-evaluation and peer evaluation in their workshop activities was introduced. Because Japanese students have less experience of discussion and are afraid of giving their own opinion, the teaching staffs take care of making good atmosphere for discussion. The students attending in the present class are satisfied for the contents.

Acknowledgements

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EXAMINING FACULTY PERCEPTION OF THEIR READINESS TO IMPLEMENT LEARNING ANALYTICS (ALeRT) IN A DIGITAL ELECTRONICS MODULE

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Abstract

This paper documents an evaluation of the School of Electrical and Electronic Engineering's implementation of the Assessing Learning Regularly for Timely Feedback (ALeRT) for a first-year module, Digital Electronics. ALeRT aims to create a technology driven framework that incorporates the application of EdTech tools and data visualization software to facilitate learning. A key element is the use of Learning Analytics (LA) to diagnose learning difficulties in situ to be able to provide high quality feedback that is personalized to individual student's needs. This school-wide pilot project involved 18 teaching staff, 60 classes, 1136 students and two technical executives for the necessary technical support. The evaluation focuses on three areas: alignment to learning design, experiences of staff and their feedback, and staff capability. A mixed-method approach was used to obtain both quantitative and qualitative data on the experience of staff in implementing ALeRT. This initially involved the use of a questionnaire with fixed and open response. Based on analysis of this data, subsequent follow-up interviews were conducted with a sample of staff to explore, in more depth, specific areas of the implementation's operation in practice. The findings were positive in terms of staff feeling that the initiative has 1) helped them to identify students who have specific learning gaps, and need further help, and 2) be able to provide immediate and focus feedback, including appropriate instructional remediation. Furthermore, the findings showed that staff were well supported in this ALeRT pilot through the optimization of the deployment of the Robotic Process Automation (RPA) for seamless integration of data collection to produce the analytical output for teaching faculty. The on-going support provided to equip faculty with the necessary knowledge for effective teaching, guided by a data-driven approach, was shown to be well constituted.

In summary, while there are areas for improvement, mainly in relation to technical implementation issues, the results suggest that the insights gained from this evaluation will prepare faculty in leveraging on the increasing affordances of using analytics in education (AiE).

Keywords: *Learning Analytics, Assessment, Feedback, EdTech*

Introduction & Research Purpose

This research documents an evaluation of a research initiative for *Assessing Learning Regularly for Timely support* (ALeRT**).** ALeRT utilized Learning Analytics (LA) to diagnose learning difficulties instantaneously to enable teaching faculty to customize student feedback in both a timely and highly focused manner. ALeRT is a partnership by the 5 Polytechnics and Institute of Technical Education to create a technology driven framework that incorporates the application of EdTech tools and data visualization software to facilitate learning. It was initially implemented in a first-year module (Digital Electronics) during the 2020 Covid-19 circuit-breaker, where students were primarily in a home-based learning mode, involving 60 classes, 18 teaching staff, and 1136 students.

The key research questions, focusing on the three broad areas of learning design, experiences and feedback, and staff capability were:

- How useful were the EdTech tools (especially those enabling LA) in identifying student learning needs and helping academic faculty to improve their teaching to these different needs?
- What teaching strategies are most effective and how are these facilitated?
- What challenges have teaching faculty faced, and how can they be improved in future?

The Learning Framework

ALeRT integrates EdTech tools that utilize the capability of LA to better understand student learning,

and then enhance instructional effectiveness and efficiency – especially the provision of instant focused feedback and differentiated instruction. It also employed an *Evidence-based Teaching Approach* derived from extensive research on how people learn and what instructional methods work best (e.g., Hattie, 2008; Willingham, 2009; Petty 2015; Sale 2020), which is essential to effectively and efficiently utilizing technology affordances. As Moroder (2013) discovered from her experience:

> Technology does not make learning more engaging or meaningful. A great lesson does this…technology can make it more effective and efficient.

Learning Analytics (LA)

Learning Analytics is defined as "the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs" by the Society for Learning Analytics. The pedagogic benefits include:

1. Identifying learners' understanding and performance levels in designated learning areas and tasks.
2. Diagnosing learner's knowledge gaps and misconceptions.
3. Customizing and personalization of instruction to individual learner needs and specific conceptual/skill areas.
4. Providing an ongoing evidence-base for future instructional planning.

The Impact of Feedback on Student Learning

The benefit of being able to assess student learning instantaneously is that it enables teaching faculty to, (1) gain insight into what students understand or do not understand in the immediate learning context, and (2) provide timely and focused feedback to facilitate the necessary remediation in situ – so to speak. Research has consistently shown that activities that enable such quality feedback is a key strategy for enhancing educational attainment. For example, the extensive meta-analysis of research on the effectiveness of different teaching methods by Hattie (2008) recorded an average Effect Size of 0.73 for feedback (i.e., students getting feedback on their work from the teacher, peers, self, or others). There are many interrelated aspects that contribute to the high impact potential of feedback on learning. Nicol & MacFarlane-Dick (2006) in synthesizing the research literature suggest the following seven principles of good feedback practice:

1. helps clarify what good performance is (goals, criteria, expected standards)
2. facilitates the development of self-assessment (reflection) in learning.
3. delivers high-quality information to students about their learning.
4. encourages teacher and peer dialogue around learning.
5. encourages positive motivational beliefs and self-esteem.
6. provides opportunities to close the gap between current and desired performance.
7. provides information to teachers that can be used to shape teaching (p.203)

Faculty Readiness

Fortunately, most SP teaching faculty, over the past decade had been acquiring strategies and skills in both using EdTech tools and employing blended learning. Blended learning has become an established mode of delivery in SP, and research over a 3-year period was conducted on its effectiveness by SP Staff (e.g., Sale, Cheah & Wan, 2017).

A Standard Operating Procedure (SOP) was developed for staff to follow on how to conduct ALeRT and is illustrated in figure 1.

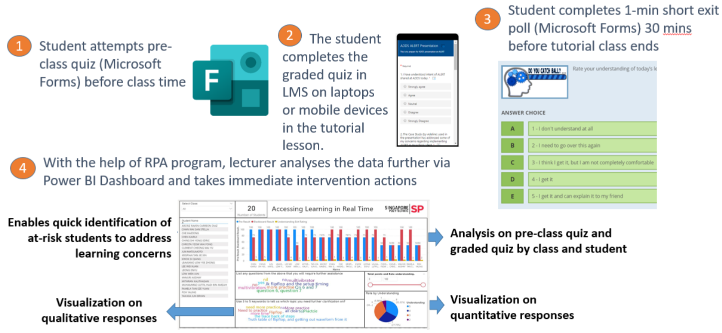

Figure 1. Rapid student feedback process

To help the teaching faculty in the implementation of the project, short videos were produced to provide easy access on the following key technical areas:

- Copying RPA program to staff laptop D drive.
- Installing Power BI and UiPath from SP's software centre.
- Uploading pre-class and exit poll to RPA.
- Uploading pre-class, exit polls and graded quiz results to RPA.

Methodology

The approach used a mixed methods approach to obtain both quantitative and qualitative data on the experience of staff in implementing ALeRT. This is to 1: initially seek a better understanding of what they are doing and how, and their perceptions of what works and what may need improving, and 2: to improve practice in how an intervention utilizing LA and other EdTech tools could enhance rapid student assessment. In this sense, there is an Action Research focus, which while

recognizing that it may not produce highly generalizable finding through extensive experimental surveys, it does as Stringer's (2004) noted:

> encapsulate the systematic qualitative research routines now becoming commonplace in the educational arena and increasingly applied by teachers and administrators as part of their work in schools. (p.6)

Within the broad AR approach, the specific methodology involved collecting both quantitative and qualitative data on the staff experience during this ALeRT implementation period. The methods employed were:

1. Survey questionnaire, including both closed and open-response items to capture a range of staff experience on implementing aspects of ALeRT (see Appendix 1).
2. Focus group interviews (where possible) with available staff to both explore in more depth the findings from the questionnaire responses, and facilitate a conversation on what worked best, how, and what can be improved in future (See Appendix 2).

Using the SOP, students were first given a set of Self-Reflective Quizzes (SRQs)/Pre-class quizzes to attempt after they had reviewed the online materials on the topic of interest before a lesson. Thirty minutes before the end of the lesson, the students had to take a supervised graded quiz and complete an exit poll. Leveraging on the speed provided by RPA, the information gathered from these three sources were then used as inputs for data analysis. The result from this analysis was made instantly available for the teaching faculty to identify areas of weakness in students' understanding. The remaining time of the lesson was then used to provide further clarification and explanation to dispel the students' doubts.

Results & Analysis

This section discusses the results in two parts: Quantitative and Qualitative.

Quantitative Data

The quantitative findings from the survey containing six statements, based on the responses of the eighteen staff involved, are presented below in Figure 2.

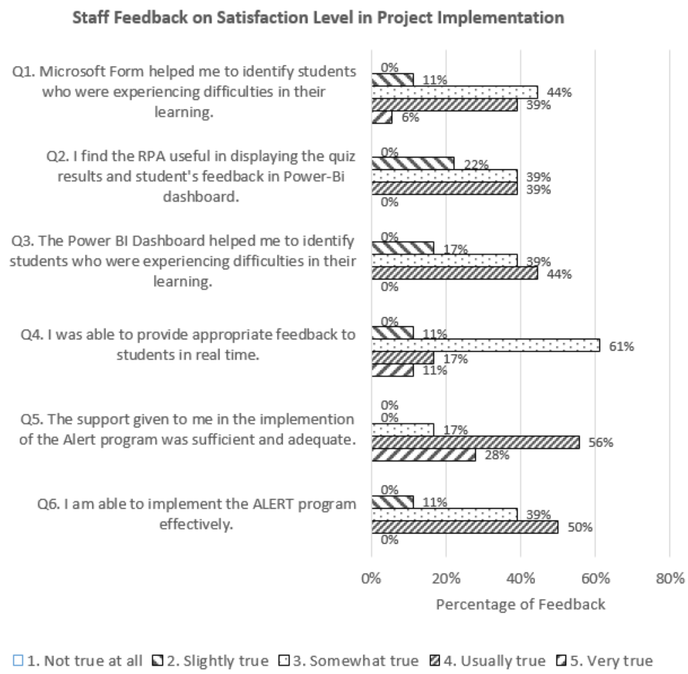

Figure 2: Quantitative Feedback on Satisfaction Level in Project Implementation

The first three statements focused on identifying the usefulness of the three main EdTech components of the ALeRT system, which were identified as being capable of providing the necessary LA and instructional support infrastructure needed for facilitating the learning environment. It is noticeable that all aspects require some improvement. There was a 6% response of 'very true' and another 50% scored slightly true.

Responses to statement four recorded only 11% responses of slightly true. 61% responses were somewhat true; 17% usually true; and 11% very true. This would suggest that the main objective of providing appropriate feedback in real-time is being met with some measure of positive staff perception, but not with a high level of conviction overall.

Responses to statement five were the most positive with no staff recording not true at all useful. 17% responses were somewhat true; 56% recorded usually true; and 28% with very true. This is encouraging, as much effort was put in to support staff in this challenging initiative.

Statement six showed that 11% felt only slightly confident, with 39% & 50% recording respectively somewhat and usually confident, respectively. This seems to relate to the overall pattern of the evaluation data, whereby staff are still in the learning process of using the EdTech tools and experimenting with the design and facilitation of pedagogic strategies within an online learning environment.

Overall, the results look promising despite the 17% percentage of "Usually true" responses to the statement that staff were able to provide appropriate rapid feedback to students. This contrasted with the relatively high percentage of staff who were confident of implementing

the ALeRT program effectively. Given that a good majority of the staff viewed the support given as sufficient and adequate, the weak link can be traced to the three main EdTech components of the ALeRT system. This area of weakness will be investigated further so that the relevant corrective actions can be implemented to enable a seamless flow in data collection, analysis, and analytical output during a lesson.

Qualitative Data

The open-response items (Statements 7-9) focused on the 'most' and 'least' useful aspects of ALeRT, and areas for future improvement. These helped to identify more specifically the reasons, with examples, underpinning the scores of the fixed response items. In terms of usefulness, the following responses were most salient:

- Identify students who are weak/need further help.
- Identify the specific areas that students are finding difficult/having problems with.
- Obtain the pre-test scores and student responses helped in scaffolding the following tutorial activities.
- Make students aware of what they do not know.
- Able to take immediate corrective action.

These responses suggest that staff were aware of the range of learning benefits that ALeRT could offer, especially in identifying students' prior knowledge, misconceptions, knowledge gaps, and being able to provide focused immediate feedback, as well as use the data to plan/modify forthcoming instructional activities.

The main positive feature is that most staff felt that they were able, given the automation process issue, to still 'provide students with appropriate and quick feedback'. Only 11% of the responses felt this was slightly true, whereas the other 89% responded with 61%, 17%, and 11% with somewhat true, usually true, and very true, respectively.

Another positive feature from the evaluation was the perceived high level of support for the implementing staff during the ALeRT implementation – both in terms of ratings and through the qualitative data. The briefings and videos provided were noted as useful, as well as the readiness of the ALeRT team to resolve issues encountered.

The data on 'least useful' aspects revealed that there were a number of issues that mitigated the potential of such beneficial learning outcomes. The more salient concerns were:

- Time consuming in entering and processing the data to generate the results.
- Too many steps involved in running the tools in class – needs to be better automated.
- Generating the dashboard did not always run smoothly – prone to turn into error.
- Using the tools employed require high specification computers, which not all staff had access to (e.g., adjunct faculty).
- While the system identified weak students for that week, it does not identify trends on student weaknesses over time.

The following four areas were identified as least effective for staff in implementing the ALeRT program, and a further short questionnaire was sent to ascertain the level of agreement with these concerns. The summary findings on the four aspects of ALeRT are presented in Figure 3.

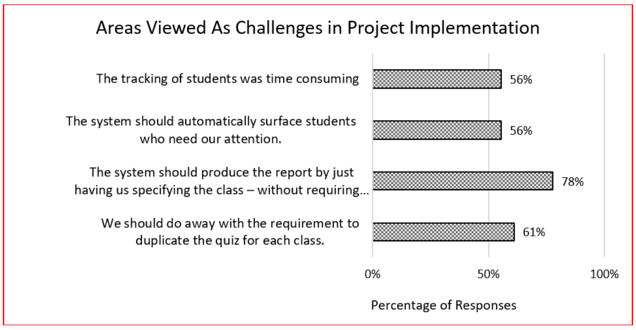

Figure 3: Areas Viewed as Challenges in Project Implementation

The areas for improvement identified reflected the least useful aspects of ALeRT program. It is likely that issues of technology implementation, especially when time consuming, will mitigate staff capability in being able to provide assessment – including feedback - effectively and efficiently. This triangulates to some extent with the responses to statements 1-3 in the main survey.

Implications for Practice & Recommendations

The data suggests that ALeRT, whether in the described or an improved format, can utilize LA in facilitating effective and efficient learning. Pedagogically, the ALeRT strategy incorporates a number of research-based high effect methods, as well as being consistent with current knowledge on how people learn best (e.g., Willingham 2009; Sale 2002). These include:

- Tests (e.g., quiz questions) of key concept knowledge to identify students' prior learning' (including gaps and misconceptions).
- Rapid and customized feedback to address learning gaps – as explained prior.
- Questions and answers focusing on student thinking, which facilitates the building of understanding.
- Activities that provide retention practice to enable students to cement learning in long-term memory.

The evaluation has illustrated the challenge of the 'implementations gap' – that is the time in which faculty need to become familiar with a new innovation to become skilled in the desired practice. For example, Gulamhussein (2013) emphasized:

> The duration of professional development must be significant and ongoing to allow time for teachers to learn a new strategy and grapple with the implementation problem. (p.3)

While the research shows positive responses to the support provided, some staff are still grappling with the implementation of ALeRT.

Online assessment offers standardised tests for a particular module with an adaptation to students' ability level and automated feedback about students' test performance. However, while research suggests benefits of direct feedback on students' learning performance, there are limited findings on how best faculty can connect the data produced to lesson facilitation and instructions.

Generally, two features appear to be important in designing formative assessment that will support learning (e.g., Wiliam, 2011). First, the evidence should be more than information about the gap between current and desired performance; it must also provide feedback about what kinds of instructional activities are likely to result in improving performance? A second feature of formative assessment supporting student learning is that students should be engaged in actions to improve learning, which might be remedial activities by the faculty, peer support or reflecting on different ways to move their learning forward. For both features, the role of the faculty is crucial. Teaching staff not only can provide different types of feedback, but also engage students more actively in the learning activities.

For example, the INP director divided his class into smaller groups, of varying compositions (e.g., random, mixed competence levels). Each group was assigned to one of four breakout rooms created and was tasked to work on past year exam questions. He assigned students to lead the groups and facilitated with scaffolding as and when needed. On completing the solutions to the questions, each group shared their tasks and answers with the whole class in Microsoft TEAM. This leveraged on peer-learning and assessment, which is a high effect instructional method, and just in time teaching.

Summary

The major benefit of the innovation was the capability to identify specific student learning needs quickly. This enabled staff to spend more time in providing scaffolding and repeated practice through appropriate examples, as well as supplementary classes when deemed useful. This is especially beneficial to students who lack prior knowledge and are presently low performing. Equally, for students who were progressing faster, staff provided extra and more challenging questions to maintain interest and enhance their learning. Some staff also encouraged these students to help their less competent peers.

This evaluation has provided current and valuable insight into the teaching staffs' experience in implementing ALeRT. Through exploring the affordances of utilizing 'analytics in education'(AiE), especially in differentiated instruction, future action research will enhance the possibility of meeting the learning needs of an increasing range of learners. It is expected that as both EdTech evolves further in this area, and with increasing staff competence in utilizing it from an evidence-based teaching approach, more rapid personalized learning is very much an educational reality.

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Appendix:

Appendix 1

Lecturer's survey on the implementation of the ALERT program (May 2021)

Please complete this short questionnaire on your experience in implementing the ALERT program. This is to help us understand what is working well, and what can be improved in future. All information provided is, of course, confidential.

* Required

SECTION A

In this section you are provided with 6 questions relating to your experience in implementing different aspects of the ALERT program. Rate your experience in one of the 5 rating circles provided.

1. Is the use of Microsoft Form helping you to identify students who are experiencing difficulties in their learning? *

	1 Not at all True	2	3 Somewhat True	4	5 Very True
Please select one	○	○	○	○	○

2. How useful is the RPA that displays the quiz results and student's feedback in Power-Bi dashboard? *

	1 Not at all useful	2	3 Somewhat useful	4	5 Very useful
Please select one	○	○	○	○	○

3. Is the use of Power BI Dashboard helping you to identify students who are experiencing difficulties in their learning? *

	1 Not at all true	2	3 Somewhat True	4	5 Very True
Please select one	○	○	○	○	○

4. Are you able to provide students with appropriate feedback in real time? *

	1 Never	2 Rarely	3 Sometimes	4 Often	5 Always
Please select one	○	○	○	○	○

5. Do you feel supported in implementing the Alert program? *

	1 Not at all True	2	3 Somewhat True	4	5 Very True
Please select one	○	○	○	○	○

6. How confident are you in implementing the ALERT program effectively? *

	1 Not at all confident	2	3 Somewhat confident	4	5 Very confident
Please select one	○	○	○	○	○

SECTION B

In this section, please offer your reflections on any specific components/aspects of implementing the ALERT program (If possible, provide 1 or 2 examples to illustrate your experience). All information provided is strictly confidential.

7. What do you feel have been the most useful aspects of ALERT for helping your student to learn effectively? *

8. What do you feel have been the least useful aspects of ALERT for helping your student to learn effectively? *

9. Please offer any reflections/suggestions that may help to improve the way ALERT can be implemented in future. *

Many thanks for your feedback in completing this questionnaire.

Appendix 2

Further questions on ALERT from the completed questionnaire (24 May 2021)

Firstly, many thanks for completing the questionnaire – it is useful feedback, especially in informing us on aspects that are only 'somewhat useful' or 'not useful'.
Please spend no more than 10 minutes on reflecting on the key findings outlined below and add anything that you feel may be useful to helping us identify what specifically can be improved and how.

* Required

* This form will record your name, please fill your name.

1. Around 50% of staff found the Microsoft Form, the RPA system and the Power Bi Dashboard to be only 'Somewhat useful'. why do you think that these were not seen as very useful? *

2. Most of us felt well supported in this ALERT program – what aspect(s) of the support provided was most useful to you? *

3. Some technology issues were identified – e.g., staff found these tools required a high spec computer and this did not work well for some students; also generating the dashboard did not always run smoothly. What technology issues were a problem for you? *

4. Tick any/all of the following if you agree with the statement: *

- ☐ The tracking of students was time consuming.
- ☐ The system should automatically surface students who need our attention.
- ☐ The system should produce the report by just having us specifying the class – without requiring the many steps we have at present.
- ☐ We should do away with the requirement to duplicate the quiz for each class.

Thank you again for your time and feedback on the ALERT program.

Partnership in building Competencies in Technical Education

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Abstract

As technology improves daily, the challenge for technical education is to keep up with the fast pace of technology development. A simple way to tackle this is to cooperate with private industrial companies. The reason is that these industrial companies need to keep their products up to date with the market expectation. Yet, education institutes focus on academic research and lack actualization experience. So, creating collaboration projects can match the commercial goals and technical education goals to become a win-win situation.

Government funding facilitates the partnership between the education institute and the private sectors in building competencies in technical education. In Hong Kong, there is an Innovation and Technology Fund (ITF) to subsidize research and development projects. One of the ITF programs is called the Partnership Research Program (PRP) which aims to support projects undertaken by designated local public research institutes in collaboration with private companies. In our approved project, "Autonomous Mobile EV-Charger" (AMEVC) which is developed under the Solar Car Project, the Vocational Training Council (VTC) takes up the role of a designated local public research institute.

With the funding, private industry partner's expense on the project can be reduced to 50% of the total project cost. This is the major advantage for private industries to co-develop projects with the education institutes.

This AMEVC project aims to provide an innovative solution for supporting Electric Vehicle (EV) charging by providing the "Fully Automated Charging Platform for Electric Vehicles". This includes a UAV with a battery pack that can charge EV at any location in any parking garage.

During the project period, VTC developers will provide guidances and resources to studends who participate in development of the project. Students could implement their knowledge learnt form classes and gain new experience by solving real problems in the industry.

The AMEVC consists of 3 parts, which are Robot Operating System (ROS), Smartphone App and mechanical design.

Students could learn above knowledge during the development of AMEVC.

As a result, the students can experience the actual manufacturing process. They can learn how to produce industrial standard drawings and managment in a project-based learning .

The main benefit of the education institute is that this project can build up the students' confidence to enter the industry in future. On the other hand, industrial companies can benefit from the increased human resources and ideas for project development. During the collaboration process, there is also an exchange of ideas.

Keywords: *ITF, EV charger, de-carbonization, eco-friendly, research*

Introduction

The ITF (Innovation and Technology Fund) is a funding administered by the Innovation and Technology Commission in Hong Kong which aims aims to increase the added value, productivity and competitiveness of our economic activities. Through the ITF, Hong Kong companies could be encouraged and assisted to upgrade their technological level and introduce innovative ideas to their businesses.

While companies are seeking ways to implement new technology to their products, the ITF provides a perfect opportunity to let local institutes to introduce new technologies and enjoy a reduction of development cost at the same time.

The institute could use this chance to provide opportunity to let students take part in a project-based learning while participating in the project. Also, this project can be used as a case study in later years.

已註解 [Cmh1]: used

Methods

-ITF

已註解 [Cmh2]: Better to add reference of ITF, for the information from ITF website directly

The ITF was established in 1999 to provide financial support for research and development projects that contribute to the promotion of innovation and technology upgrading in Hong Kong. There are six major research funding programmes under the ITF. And VTC joined Partnership Research Programme (PRP) which means to support collaborative R&D projects undertaken by R&D centres, universities, and other designated local public research institutions with private companies.

Under the PRP and the collaborative stream, the industry co-applicant should contribute, in the form of industry sponsorship, at least 50% of the total project cost (or 30%-49.99% of the total project cost).

The ITF has been funded 8,505 projects, and 4019.3 million of HKD has been approved in year 2021. This shows Hong Kong determination on encouraging the development of R&D and re-industrialization of Hong Kong.

-Coverage of the expenditure

All project funds (including ITF grants, sponsorship and other income derived from the project during the project period) must be used exclusively for the project and incurred within the project period. It may be used for covering the costs of manpower employed specifically for carrying out the project, new equipment procured specifically for carrying out the project, and other direct costs which are specifically incurred for carrying out the project.

-Project coordinator

The project coordinator is responsible for overseeing the project generally; monitoring its expenditure and ensuring the proper usage of project funds in accordance with the approved budget and other guidelines and instructions set for the projects; liaising with and answering all enquiries/requests raised by the Innovation and Technology Commission (ITC) for information and clarification on all aspects of the project; and attending progress meetings on the project.

-Patent registration fee

Patent registration fee for functional inventions directly relating to the project may also be included in the budget. The above notwithstanding, the patent registration fee charged to the project account should not exceed HK$250,000.

-Audit fee

The maximum funding support allowed for an annual/final audited accounts of a project costing less than HK$1 million, between HK$1 million and HK$5 million and more than HK$5 million should not be more than HK$8,000, HK$14,000 and HK$20,000 respectively.

-Payment schedule

1. The industry co-applicant should contribute, in the form of industry
sponsorship (excluding other sources of financial contribution), at least
50% of the total project cost (or 30%-49.99% in the case of R&D Centre
projects with exceptional approval from ITC) within the project period.
The ITF funding is released on a matching basis, i.e. the contribution from
the industry co-applicant should be made first and the disbursement from
ITF will follow.

2. ITF funding will normally be disbursed on an annual basis, subject to
satisfactory project progress against agreed milestones and due payment of
the industry sponsorship and other sources of financial contribution.

Schedule of the project period

The duration of the project period should not exceed 36 months in general. There is however no minimum time requirement.

-VTC Solar Car Team (SOPHIE)

SOPHIE Team is a team in IVE Engineering Discipline formed in 2009 that develops solar car. SOPHIE Team have been building solar powered electric vehicles for more than ten years. They are experts in building electric vehicles and utilizing solar power. In 2019, solar-powered car SOPHIE 6s won the 3rd place in Australia's World Solar Challenge 2019 .

SOPHIE Team cooperates with local industrial partners to develop their technologies for solar car while their industrial partners could use SOPHIE Team experimental result for new product development.

-Cooperation with industry partner

The industrial partner (Totex) is a company that produces battery modules since 1985. Their experienced engineers are capable of design and produce safe and reliable battery management systems. And Totex has been a partner of Sophine Team for their battery modules since 2017. With the experience of building battery modules for SOPHIE, Totex developed a smart battery management system for electric vehicles. Totex discovered this battery technology contains great potential of being a popular product in Hong Kong, and they are looking for a chance to make use of their battery technology. In 2018, Totex started designing their EV charging device and co-developed a mobile EV charger (MOBO I) with VTC, and HKPC in 2020.

-ITC (Innovation and Technology Commission)

The ITC is a department under Hong Kong Government that responsible on promote and support the research and development, and technology transfer and application. In this ITF funded project, ITC provides advice and comments on how to apply for ITF funding. ITC will conduct a screening on the applications for ITF. To decide which project needs to be funded. In order to make sure the project meets ITF funding's requirements, ITC will evaluate if the project has market value, how this project could contribution to the society, and level of innovative in the project.

ITC facilitates local business with their knowledge hub that provides platform for various of technologies that are high quality and ready to use. That could speed up the lineup process between local business and research institutes in Hong Kong.

-Application of ITF

已註解 [Cmh3]: Should be VTC Solar Car Team

已註解 [Cmh4]: 2019

已註解 [Cmh5]: Add reference

During the cooperation of SOPHIE team, Totex discovered the market in portable EV charging devices. They are decided to make an upgrade version of MOBO I, which is a fully automated mobile EV charger. However, they are hesitated to start a that project due to high development cost and leak of development experiences in robotics sector. Without sufficient support, Totex almost abandoned their development plan on AMEVC. They decided to seek advice from VTC and ITC. After meeting with VTC and ITC, Totex receives information about ITF funding. Knowing that 50% of the development cost will be subsidized, Totex decided to enroll the Partnership Research Programme (PRP) under ITF funding.

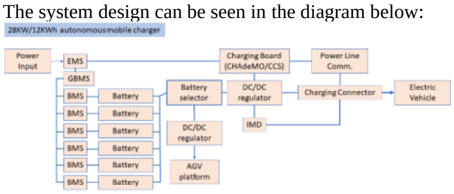
In September of 2020, Totex decided to upgrade the EV charger into a fully automated EV charger by including an AGV platform into their mobile EV charger (AMEVC). And the total project cost was ~$550,000 HKD which is a relatively small-scale project compared to a regular research project.

-The project timeline

With the previous experience of co-developing mobile charger with VTC, Totex decide to initiate this project with VTC. So Totex applied the ITF with VTC as their partner institute in 2021. And the proposed timeline originally is as follows:

1. Jan 2021 - May 2021Application of ITF funding
2. Jun 2021 - Nov 2021Hardware design, development and relevant testing for the automatic EV mobile charger platform including the charger connector inserting mechanism and recharging station
3. Dec 2021-May 2022 Software development and testing for the recharging station, self-developed smart phone app and hardware integration of the AMEVC

The system design can be seen in the diagram below:

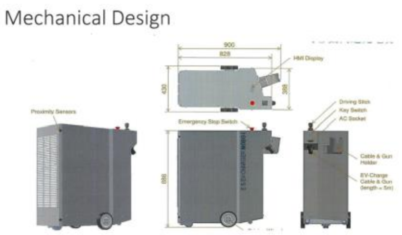


[Figure 1.] System design of EV charger

The multiple battery module design enables fast recharge of battery and charging of EV. The battery selector will select charged batteries for EV charge while recharge other batteries simultaneously. With this configuration, the charger could supply ~100A/430V to EV and refill EV's battery up to 80% in 30 mins.

The machinal design looks alike to the pervious developed MOBO I as they share similar energy management system and differential driving system.

The machinal design was as diagram below.



[Figure 2. Original machinal design of MOBO I]

In the software side, developer uses ROS as its software platform for navigation and mapping. ROS enables a rapid prototyping for robot development as it has standardized protocol and wide range of open-source library for navigation, motion control, computer vision and AI development. Developer can focus on the application development and spend less effort on the integration of the libraries.

Paedology

ROS is an open-source platform which provides various kinds of libraries in robotics research and development. This is a prefect tool for learner who interested in about robotics because there are lots of tutorials and well documented libraries online. Also, it's modular design enables a very flexible environment for rapid prototyping of robotic software. Students could learn quick by doing experiments on both the simulation environment and AGV platform.

Since the carpark is a less regulated environment than a standard laboratory. There are no clean lines to follow, no smooth and flat floor, speed bumps between sections in the carpark and the lighting condition is far from ideal environment. It needs a robust navigation method to maintain its accuracy. Only using either an odometry or a vision-based positioning system would not be a good option. Students needs to implement sensor fusion and signal processing in a real environment rather in simulations. That could give new insights to students about how to increase a robustness of an automated system.

However, due the pandemic of covid19, the plan could not be executed as expected. After discussing with Totex about the situation, the new timeline has been updated. The original plan was postponed for 6 months.

Results and Discussion

Results

The development is still in progress due to the postponement, but the industrial partner is delighted to see the development progress. And they showed great interest on initiating a new project to apply for ITF funding about mobile solar energy storage device. Due to students need to study at home during most of the project

period. So, the student assistant recruitment will be postponed until next project.

Discussion

-Benefit to local industrial partner

With the help of the technology and funding, local business can adopt new technology with less concern about the cost of development. They could enjoy a reduction of 50% of their development cost and receive a full ownership of intellectual property of the development result. With huge reduction of development cost, company became more welling to development new technology in Hong Kong.

-Benefit to institutes and VPET students

By cooperating with industrial partners, VTC could provide opportunities for students to participate in project to provide a project-based learning experience for them. Moreover, VTC could make use of this chance to increase recognition of research and development capability amount industrial sector. VTC could use this project as example to initiate more cooperation with industrial partners.

By letting students to participate in projects. Students could gain experiences and learn by engaging in real-world and meaningful projects. That could improve students' problem-solving skill and creativity by tackling the problem during the project.

In this project, students studying in higher Diploma of Electrical engineering, Electronic Engineering, Mechanical Engineering and Computer Science be allocated to assist the development in this project. The developer would assign tasks and guide them to assist the development of the project. While solving the problem, they will work with students from other subjects. Eventually, students would learn how to cooperate and exchanges idea with people from other disciplines. Also, they could gain an accurate and deep understanding of how to implement new technologies to products.

While students are participating in the project, industrial partner could discover students' talents by observing their performance in the project. That could encourage industrial partners to employ VPET graduates in their companies.

-Benefit to the Society

With the climate change due to overuse of fossil fuel, humanity is facing a great challenge on how to survive in the future. While the temperature rising in these decades, extreme weather endangers world's food supply, floods and droughts happens more frequent than ever. Heat waves becomes longer and hotter as heat-trapping carbon pollution continues to build up in the atmosphere. Action must be taken to trim down the CO_2 concentration in the air. Low-carbon economy is one of the ways to limit the carbon footprint.

Due to high fuel price and the needs of reduction on carbon emissions, the demand of EV (electric vehicle) grows rapidly in recent years. (In March 2022, 1656 out of 3921 newly registered vehicles uses battery as power source, figure from data.gov.hk) However, the number of EV charging station could not get up with the number of EVs. Also, most of the current carpark is not ready to facilitate the high demand of power during EV charging in peak hours. The AMEVC will be perfect solution to top off the shortage of EV charger. With the AMEVC, power can be temporarily storied in the battery and delivery to EV user after charging. So, the EV users don't need to look for EV charging enabled parking space while the EV charger will reach the user as requested. That could encourage drivers switch their fossil fuel vehicle to an electric car which is much quieter and energy efficient. Thus, the emission of CO_2 and other harmful gases can be reduced.

Conclusions

The ITF project provide a subsidy for institutes and local business to adopt new technologies. With the subsidy, entrepreneur would reduce their hesitation on the investment on employing new technology in product development. Thus, that could shorten the time to market of new technologies.

On the other hand, ITF funded projects could enhance the quality of teaching and learning experience by providing research and practical learning opportunity for students for VTC developers and students. Moreover, the prototype could be use as an teaching tool for engineering students. Also, developers could acquire new insights while cooperating with industrial partners.

As long-term cooperation has been carrying out with the help of ITF funding, that will enhance the relationship between VTC and industrial partner. Through this good relationship, local industry would have additional incentive to hire VPET graduates, and new students would be more likely to enrol in VPET courses.

Acknowledgements

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Educational Practices for Teenage Students to Improve Quality of Architectural Works - An Approach Using Evolution Thinking at Anan KOSEN (National Institute of Technology)

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Abstract

At National Institute of Technology (Kosen), Japan, early architectural education is provided from the age of 15. However, it is difficult to train younger people with little social experience as engineers with design abilities in the current VUCA (Volatility, Uncertainty, Complexity and Ambiguity) era. Although design thinking has been used for engineering design education in previous studies, younger students may not have a backbone to define problems. Also, while design thinking emphasizes teamwork, it is difficult to always give issues through teamwork in actual classes. Therefore, in this research, we focused on evolutionary thinking in which anyone can demonstrate creativity and that can be implemented by individuals or groups.

In this report, students of Kosen's Anan College are divided into two control groups and challenged to an architectural competition where they must propose an outdoor space for sustainable activities by revitalizing communities in the centre of a local city with a limited budget. Their evaluations are then compared from September to October 2021. Two control groups were given 3 classes: the 1st class was a description of the competition, the 2nd was concept making, and the 3rd was a design check. In the 2nd class, one of the two control groups (26 students of the 2nd grade, 16 years old) was given a lecture for using the evolution thinking, the other (25 students of the 3rd grade, 17 years old) was given a lecture on design thinking. Their work was evaluated with a 5-point rubric (A: Regenerate the community, B: Useful for sustainable activities, C: Form with the concept, D: Fits within budget, E: Design on paper matches the concept.)

As a result, the second graders had higher evaluation points for two categories (A: regenerate the community, D: fits within budge) and a significance level of 0.05. In addition, it was confirmed that the second graders were evaluated higher overall by the covariance structure model. This result suggests that evolutionary thinking may be effective in early architectural design education.

Keywords: *adaptation, mutation, design thinking, teenager*

Introduction

National Institute of Technology (NIT), Anan College (NITAC) is one of 51 schools called "Kosen" in Japanese with 55 campuses throughout Japan, and is located in Anan City, Tokushima Prefecture, about 120km southwest of Osaka. Kosen is a higher education institution that accepts junior high school graduates and provides integrated education for five years in order to train engineers needed by local society, unlike the university education system. NITAC has an advanced course that provides specialized education for two years after a five-year main course, and is accredited by the Japan Accreditation Board for Engineering Education (JABEE) joined by the Washington Accord.

One of the educational achievement goals (competencies) of NITAC, which is common with the JABEE program, is to train "engineers who emphasize manufacturing and have design ability to realize technical ideas and creative thinking." Achieving this capability is not easy for Kosen students who have less experience with social participation than general college students over 18 years old in the era of VUCA where major changes in the social environment such as international political and economic position and climate change are occurring.

In engineering education, many educational practices incorporating the design thinking have been reported in order to accurately grasp issues and improve the ability to design in such a complicated society. Design thinking is a competency that organizes the activity process of professionals practicing design, and a typical model is the "five steps" of the Hasso Plattner Institute of Design of Stanford University known as d.school. The five steps consist of empathy, problem definition, creation, prototype, and testing as shown in Fig. 1, and the team examines the process from divergence to convergence and from abstraction to the

concrete. Although the effectiveness of design thinking in engineering education has been recognized, it is difficult to make prototypes in architecture classes. In addition, in the actual educational field, it is necessary to improve not only teamwork but also the ability to design individually.

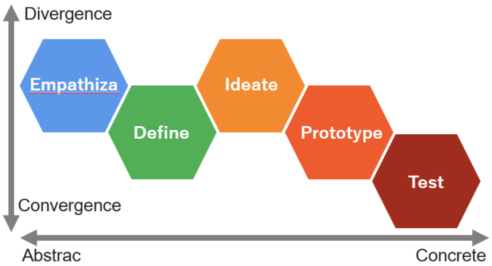

Fig1 5 steps of Design thinking

Therefore, NITAC decided to incorporate evolution thinking, which is a new thinking method for design that can be applied to both individuals and teams, into engineering education, so that "everyone can demonstrate creativity." Evolution thinking is a design idea method advocated by co-author and designer Eisuke Tachikawa, and a book showing its contents was published in Japan in May 2021.

In this report, among the design education practices related to architecture conducted at NITAC, we compare how the evaluation of student works differs between the case of education using the evolution thinking and the case of the design thinking and engineering.

About the evolution thinking

Eisuke Tachikawa systematizes his creative process as a designer in a system called evolution thinking, that applies to creativity the process by which living things and nature have survived through repeated mutation and adaptation for 4 billion years. Specifically, in evolution thinking, it is assumed that there are nine types of mutations (Fig 2) in living things and nature, and the number of mutations is examined for X that we want to evolve. Contingency is emphasized many ideas are presented, however most of them are weeded out in the process of adaptation.

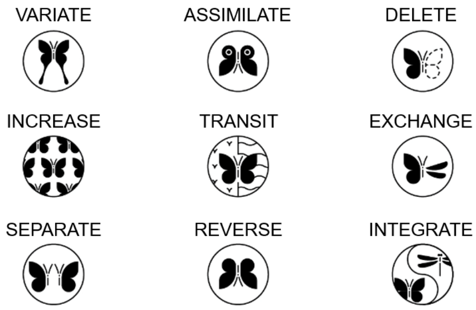

Fig 2 Nine types of mutations in evolution thinking

Adaptation (Fig 3) is performed simultaneously by phylogenetics and futurology with temporality, and analysis and ecology with spatiality. Repeating these mutational and adaptive studies over and over again is similar to the evolution of living organisms over generations, creating a concept that survives change and selection. It is an approach to advance the design.

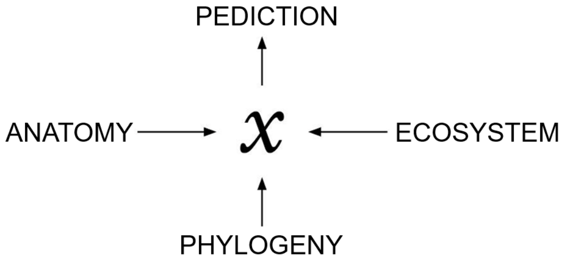

Fig 3 Four types of adaption in the evaluate thinking

The process of mutation accidentally yields a myriad of ideas, which are autonomously and naturally selected by the process of adaptation. By going back and forth through the process of mutation and adaptation many times, it is said that it is possible to create a concept that survives change and selection.

About the competition

The competition that the students entered was set up at the cityscape along a river that runs through the center of Tokushima City, and was held by the Tokushima Branch of the Japan Federation of Architects and Building Engineers Associations from September to October 2021 with the aim of creating a place to revitalize the community. It was an idea competition for outdoor architectural spaces that led to the promotion of activities. The submissions were to be put together on one A3 sheet, and the type of drawing was not specified. However, the budget was set at about 150,000 yen (about $1,100), and it was required that it could actually be created.

About 90 works were submitted to the competition, and a student of NITAC received the excellence award (Fig 4), and the works were actually created and installed in the cityscape (Fig 5).

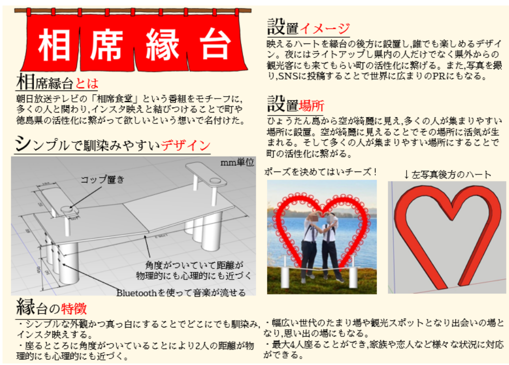

Fig 4 Student work selected for an excellence award

Fig 5 Student work actually produced and installed in the cityscape

Evaluation of student works and statistical analysis of how to proceed with classes

A total of 51 students (Table 1), including 26 second graders (19 males and 7 females) and 25 third graders (26 males and 25 females), participated in the class and entered the competition. Classes consisted of three 90-minute lectures in each grade. In the first class we explained the competition, and in the second class they were given guidance on studying the concept. Then, in the third class, we taught design based on the concept. After that, the students submitted their work to the competition. In the second class of the second grade, instruction using evolutionary thinking was given, while in the second class of the third grade, instruction using design thinking was given.

Table 1 Number of students by gender and grade

	Men	Women	Total
2nd grade	19	7	26
3rd grade	20	5	25
Total	39	12	51

The work was evaluated by three faculty members on the five items shown in Table 2.

Table 2 Five items of evaluation

Evaluation items	Point
A: Regenerate the community	Excellent is 1, Good is 0.5, Not good is 0
B: Useful for sustainable activities	
C: Form with the concept	
D: Fits within budget	
E: Design paper matches the concept	

The evaluations of A and B are evaluations related to the concept, and evaluated whether they are proposals that lead to the regeneration of the community and their sustainability. In the evaluation of C, we evaluated whether the concept and the form have a relationship. Even if the evaluation of A and B is not sufficient for the concept, C is evaluated if the concept and form are connected. D was evaluated whether it could be created with the budget constraint of 150,000 yen. E is an evaluation of the design on paper. We evaluated whether the paper design was in line with the concept.

Table 3 summarizes average score of total and every evaluation items by grade and gender.

Table 3 Average score of total and every evaluation items by grade and gender

	Grade		Gender	
	2nd	3rd	Women	Men
A	0.975*	0.840*	0.917	0.923
B	0.885	0.800	0.833	0.846
C	0.885	0.720	0.750	0.821
D	0.692*	0.320*	0.500	0.513
E	0.808	0.920	0.917	0.846
Total	4.269*	3.600*	3.941	3.911

Regarding the overall evaluation, by grade, the second graders were 0.669 points higher than the third graders. Testing for the difference of two populations of this case was significant at 5% on both sides. In A and D, the second graders were 0.135, 0.372 points higher than the third graders, and 5% significant on both sides. In B, C and E, the second graders were higher, however not statistically significant.

All evaluation items were not statistically significant by gender difference. Neither gender difference in the second grade nor in the third grade were found to be statistically significant.

From this result, it was found that the second graders who learned about the evolution thinking had higher scores for the overall evaluation and the two evaluation items, A: Regenerate the community and D: Fits within budget, than the third graders who learned about design thinking, which was statistically significant.

Presentation of the whole structure by the covariance structure model

A covariance structure model is created to see the overall structure of the evaluation of student work by grade. The variables used are shown in Table 4.

Table 4 Variables used in covariance structure model

Latent variables	Observed variables	Basis for numbers
Grade	Grade	1: 2nd grade 0: 3rd grade
Evaluation	A: Regenerate the community	1: Excellent and good 0: others
	B: Useful for sustainable activities	
	C: Form with the concept	
	D: Fits within budget	
	E: Design paper matches the concept	

Fig 6 shows the covariance structure model created. It can be seen that all the evaluation items improved for the grade that is the second grade where students took the lesson about evolutionary thinking. This model has chi-square as 17.538, degree of freedom is 12, Goodness of Fit Index (GFI) is 0.883 and Adjusted Goodness of Fit Index (ADFI) is 0.805 that exceeds 0.8 indicating that this model is explanatory.

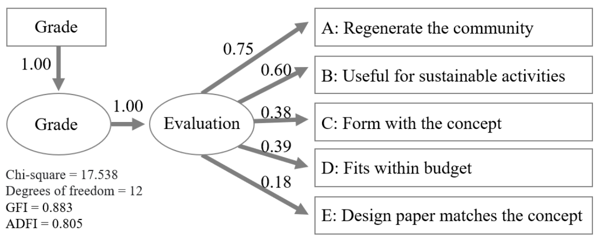

Fig6 covariance structure model

Conclusions

In this study, 51 young students aged 16 and 17 were asked to hold a competition on the design of outdoor spaces that sustainably regenerate the community in the center of a local city, and their work was evaluated. Here, the students were divided into two target groups. In one group of lessons, we used evolution thinking to think about the concept, and design thinking for the other group. As a result, it was confirmed that the group who gave the lesson with evolutionary thinking had higher evaluations overall and for the evaluation of two items (concept and budget), which were statistically significant. In addition, when a covariance structure model was created and the overall structure was examined, it became clear that the group who took the evolutionary thinking class had a higher evaluation as a whole.

This suggests that evolutionary thinking may be useful in engineering education for young people, especially for design.

In the era of VUCA, evolutionary thinking is needed to foster "engineers who emphasize manufacturing and have design ability to realize technical ideas and creative thinking," which is the educational goal of Anan National College of Technology, and which is common with JABEE. We will study the educational practice of this. And I would like to establish a more effective early engineering methodology.

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COLLABORATIVE EDUCATION IN ENGINEERING USING THE TRAINING SHIP "OSHIMA MARU"

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Abstract

In engineering education at National Institute of Technology (KOSEN), the MCC (Model Core Curriculum), JABEE (Japan Accreditation Board for Engineering Education), and other quality assurance frameworks require (1) education that fosters teamwork skills, (2) AL (Active Learning) and PBL (Project / Problem Based Learning), and (3) collaboration with different fields (other disciplines). Under such circumstances, Oshima College set up a lecture utilizing the "Oshima Maru", a training ship used for shipping technology education in the Dept. of Shipping Technology, as a partner for collaboration in different fields. The fields of maritime engineering education and marit ime transport (merchant marine) education have an engineering aspect, but they also have a different nature from the engineering fields, as they are fields for acquiring the skills to operate ships. By collaborating with such a field, we expect to foster different and diverse perspectives that is necessary for engineers. Creation and Research Practice III (CRP3) in the 5th grade of the Dept. of Information Science and Technology and Creative Engineering Exercise (CEE) in the 1st grade of the Advanced Course of Electronic and Information Technology Systems are organized in collaboration with "Oshima Maru". In CRP3, project groups consisting of several members are organized to conduct exercises in the role of a salesman who proposes a new system to the training ship "Oshima Maru". The program aims to develop the ability to analyze current issues, utilize knowledge acquired in the Dept. of Information Science and Technology, investigate technologies to overcome such issues, and create new systems. CEE has set a specific goal of "establishing a disaster communication network on remote islands" to develop human resources who can utilize advanced technologies such as AI, IoT, and robotics, and aims to develop human resources who can build a system centered on the training ship "Oshima Maru" and respond to various issues in a team. In this report, we present the status and results of these efforts.

Keywords: *collaborative education, different field, training ship, team work, AL, PBL, MCC, JABEE*

Introduction

In engineering education at KOSEN (National Institute of Technology), quality assurance frameworks such as MCC (Model Core Curriculum) and JABEE (Japan Accreditation Board for Engineering Education) require (1) education that fosters teamwork skills, (2) introduction of AL (Active Learning) and PBL (Project / Problem Based Learning), and (3) collaboration with different fields (other discip lines).

Under these circumstances, Oshima College has set up a lecture course in which the training ship Oshima Maru used for merchant marine education in the Department of Merchant Marine, is utilized as a partner for collaboration in different fields. The lectures are organized in collaboration with the Oshima Maru in the Creative Exercise III for fifth-year students of the Department of Information Engineering and in the Creative Engineering Exercise for first-year students of the Department of Electronics and Information Systems Engineering.

This report describes the status and results of these efforts.

Outline of cooperative engineering education

Requirements for engineering education: KOSEN (2018) introduced the MCC in FY2018 to assure the quality of its education. The MCC presents a "core," which is the minimum level of competence and content

Figure 1. The training ship “Oshima Maru” with Oshima Bridge

Table 1. Specifications of the training ship Oshima Maru

Launch date	September 9, 1993		
Ship Name	JK5169		
Gross Tonnage	228 tons		
Dimensions	Length 41.0 m	Width 7.6 m	Depth 3.5 m
Main Engine	1Diesel Engine（1300ps/370rpm)		
Maximum Trial Speed/Speed	13.69knot/12.50knot		
Cruising Distance	Approx. 2,100 n-miles		
Maximum Capacity	Crew 9	Others 49	Total 58

to be acquired that all students of KOSEN should aim to achieve, and a "model," which serves as a guideline for further advancement of the education of KOSEN. This is the core of engineering education at KOSEN.

As a quality assurance system for engineering education, our college has introduced the JABEE accredited program, which is a program that enables students to obtain a professional engineer's license, which is connected to the national qualification of professional engineer.

MCC requires "cross-disciplinary abilities that engineers should possess". JABEE (2017) requires that "when working as an engineer in actual business, it is expected that there will be opportunities to work on problem solving, etc. in collaboration with engineers who specialize in fields other than one's own, or with non-technical personnel (designers, sales personnel, users, etc.) who have different roles. Therefore, it is desirable to create similar educational opportunities to foster the ability to work in teams". Furthermore, JABEE states that it is necessary for students to at least become aware of the necessity and importance of teamwork with others in different fields and positions.

In engineering education at KOSEN, (1) education to foster teamwork skills, (2) introduction of AL and PBL, and (3) collaboration with different fields (other fields) are required within the framework of quality assurance such as MCC and JABEE.

Training ship Oshima Maru: The college has a history of 125 years since its opening as a merchant marine school (shipping technology school), and it has been 55 years since it became a technical college. The training ship Oshima Maru, which is used for shipping technology education, is now in its third generation (see Figure 1). Table 1 shows the specifications of the training ship Oshima Maru. The fourth generation of the Oshima Maru is scheduled to be completed in March 2023.

The college consists of three departments (Dept. of Shipping Technology, Dept. of Electronic-Mechanical Engineering, and Dept. of Information Science and Technology). The Oshima Maru is used as a training ship for the Dept. of Shipping Technology , and is used for daily practical training.

Meaning of collaboration with the training ship Oshima Maru: The fields of maritime engineering education and maritime transport education (merchant marine science) have an engineering aspect, but they are different from other industrial fields in that they are fields for acquiring the skills to operate ships. By collaborating with such a field, it is possible to foster a different perspective necessary for engineers.

In the Creative Exercise III (CRP3) in the 5th grade of the Dept. of Information Science and Technology, the fourth generation Oshima Maru is scheduled to be newly built, and the students collaborate on a specific problem, "a proposal that could be adopted for the new shipbuilding," using the training ship Oshima Maru itself as the target.

In the Creative Engineering Exercise (CEE) in the 1st grade of the Advanced Course of Electronic and Information Technology Systems, the students will work together to build an application system using the training ship Oshima Maru.

Creation and Research Practice III (CRP3)

In this section, we present the content and current results of CRP3 conducted in the 5th grade of the Dept. of Information Science and Technology.

Details of implementation: In the CRP3, a class of about 40 students in the 5th grade of the Dept. of Information Science and Technology organizes project groups consisting of several members and conducts exercises as "salesmen who propose new systems" on the training ship Oshima Maru.

The students are asked to "analyze the current functions of a new ship and propose improvements" in order to propose a system or mechanism that they think should be incorporated into a new ship. The aim is to develop the ability to analyze current problems, utilize knowledge acquired in the Dept. of Information Science and Technology, investigate technologies to overcome them, and create new systems.

The specific steps of the practice are as follows.

[1] Detailed explanation of the Oshima Maru and survey of its current status

[2] Survey of operational issues through boarding practice

(a) Ship briefing (Bridge) [1]

(b) Ship briefing (Engine) [1]

(c) Boarding practice (Bridge) [2]

(d) Boarding practice (Engine) [2]

Figure 2. CRP3 phase 1: Survey phase

(a) Group discussion for new proposals [3]

(b) Short presentation of a draft of the new proposal [4]

Figure 3. CRP3 phase 2: Discussion phase

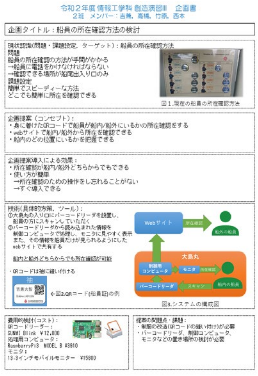
[3] Discussion for new proposals and detailed planning of the project
[4] Short presentation of a draft of the new proposal
[5] Brush-up
[6] Presentation of results

The above steps are followed up to proposal [6]. In [3], based on [1] and [2], the planning of the system to be proposed is discussed. In [4], the results are presented to the Oshima Maru crew and their opinions are heard. The plan is brushed up in [5] with good opinions obtained.

Each step is classified into the following three phases.
CRP3 phase 1: Survey [1]-[2]
CRP3 phase 2: Discussion [3]-[5]
CRP3 phase 3: Proposal [6]

Figure 2 shows the Oshima Maru crew explaining the various departments on board during the survey phase (CRP3 phase 1). As shown in Figure 2(a) and (b), the participants are divided into the bridge (deck) and engine room (and control room) when the ship is docked, and are briefed on how the ship is operated. The students then experience the actual operation of the ship in [3] (see Figures 2(c) and 2(d)).

(a) Proposal example 1 (in Japanese)



(b) Proposal example 2 (in Japanese)

(c) Presentation of results [6]

Figure 4. CRP3 phase 3: Proposal phase

Figure 3 shows the discussion phase (CRP3 phase 2). In Figure 3(a), based on the issues serveyed, the proposed project is discussed. Figure 3(b) shows a short presentation of the draft plan to the crew of the Oshima Maru, and the process of listening to their opinions.

From the above process, a proposal is finally submitted in the proposal phase (CRP3 phase 3). The proposal is prepared for the following five items: <1>Current situation (problems and issues, targets), <2>Proposal (concept), <3>Effects of the proposal, <4>Technology (specific measures, tools), Cost (cost), and <5>Problems and issues with the proposal (Figure 4(a) and 4(b)), (See Figure 4(a), (b)). Based on this proposal, the results are presented [6] as shown in Figure 4(c) and evaluated by the Oshima Maru crew.

Results: In this practice, each student is required to submit a summary report after presenting the results, and the following are excerpts from their comments in the FY2021 report.

- What I felt most through this practice was the importance of interviews. If you do not research and ask about an industry you do not know, you will end up saying something misguided. It was difficult because I had to do a lot of research before thinking about the content of my proposal.
- In order to propose a project, present it to others, and have it adopted, the person making the proposal must not only focus on getting his or her own proposal accepted, but must also have a great deal of knowledge in the field of the person being proposed to.
- It was an unprecedented experience for me to receive opinions from clients (Oshima Maru crew

Table 2. Evaluation items for class evaluation

Item No.	Evaluation item	Satisfaction†	Attitude‡
1-11	*Evaluation items related to class implementation methods and content*		
12	Have you been able to "learn how to see and think" in this area?	✓	
13	Did they clearly indicate "how it will help you in the future?"	✓	
14, 15	*Evaluation items related to class implementation methods and content*		
16	Looking back on the class, was it "satisfactory"?	✓	
17	To what extent did you "understand" the class content?	✓	
18	Were you "engaged" in the class during class?		✓
19	Have you done any "preparation/review" for this subject? (including assignments and reports)		✓
20	Did this class make you "interested" in this subject?		✓

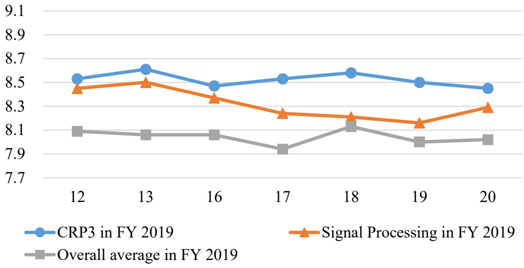
† Student satisfaction and understanding
‡ Evaluation of one's attitude toward the class

members), prepare proposals and presentation materials, clarify and summarize opinions within the group, and make presentations. I felt that it was important to look at ideas from different perspectives and objectively judge whether they are valid or not.

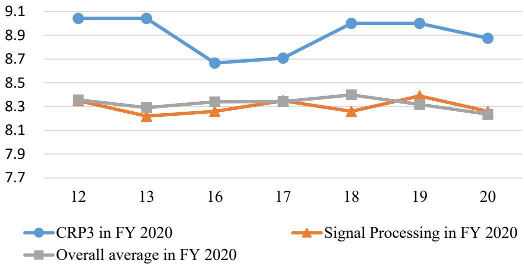
As described above, this practice has provided a good experience for students to understand the difficulty of tackling problems in other fields (different fields) and to make proposals using knowledge in their own fields.

The college conducts an annual class evaluation of all classes. There are 20 items on a 10-point scale in the evaluation, including items related to the method and content of the class, such as the content of the class, the way the class is given, and the degree of progress of the class, as well as items to evaluate the students' satisfaction with the class, the results obtained, and their self-evaluation of how they worked on it. Table 2 shows a summary of the items of the class evaluation regarding the students' satisfaction and understanding of the class and their attitude toward the class.

Figure 5 shows a comparison of the evaluation items (12, 13, 16-20) of the CRP3, the author's general lecture (Signal Processing) in the same students, and the overall average of the college for the FY2019 and FY2020. Although there are variations among the classes evaluated in each year, the evaluation values of the CRP3 are higher than the overall average in all of the evaluation items (12, 13, 16-20), and they are higher than the evaluation values of the regular lecture-style lecture



(a) Class evaluation of FY 2019 [10-point scale]



(b) Class evaluation FY 2020 [10-point scale]

Figure 5. Comparison of class evaluation results

(signal processing) that the author teaches alone in all of them. In particular, the evaluation value of item 12, "Have you been able to "learn how to see and think" in this area?" of my own field, was particularly high, suggesting that the students were able to understand the characteristics of my own field through collaboration in other fields. In item 13, students were also able to sense "how their field will be useful in the future," which suggests that they were able to understand how to utilize their field in solving actual problems. Furthermore, the high evaluation items (18-20) of the students' attitude toward the exercise suggests that the exercise was interesting.

Creative Engineering Exercise (CEE)

In this section, we present the content and current results of CEE conducted the 1st grade of the Advanced Course of Electronic and Information Technology Systems.

Details of implementation: CEE has set a specific goal of "establishing a disaster communication network on a remote island," and has placed the training ship Oshima Maru at the core of the system, aiming to develop human resources who can utilize advanced technologies such as AI, IoT, and robotics, and who can respond to various issues in a team. Figure 6 shows an overview of the disaster response system.

The college has trained practical engineers, and is now working to develop human resources capable of utilizing advanced technologies such as AI, IoT, and robotics to cope with recent large-scale disasters. Although responding to large-scale disasters is an issue that needs to be promoted in modern society, there is a shortage of human resources in domestic companies, and it is necessary to work on human resource development

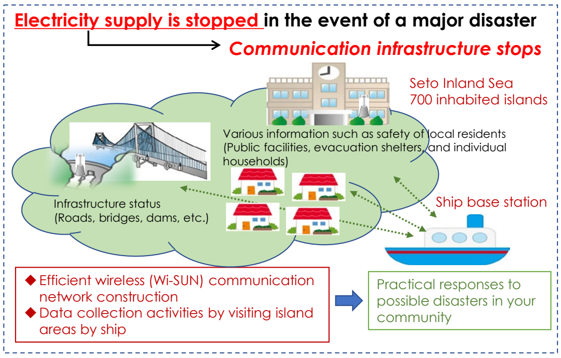


Figure 6. Overview of disaster response system

as soon as possible. Therefore, the college has launched the following project.

In order to develop human resources who can utilize advanced technologies that are essential for responding to large-scale disasters, we will develop teaching materials for Wi-SUN communication exercises and sensor terminal design exercises, and conduct large-scale disaster response training using the training ship Oshima Maru to enhance the education.

This exercise will be conducted as part of the above project, and will be divided into the following phases to achieve these goals.

CEE phase 1 [Advanced technology understanding]: Understand the technologies to be used for PBL study in CEE phase 2 through training sessions on advanced technologies (AI, IoT, robotics).

CEE phase 2 [PBL (AL)]: In order to achieve the goal of "Establishment of disaster communication network in remote islands", students will be divided into groups of several members, each group will set its own theme, and work on the investigation of problem-solving systems in a PBL (AL) format.

The names of the themes for FY 2018 are as follows

- Development of information and communication system in remote islands assuming a large-scale disaster and proposal of water transportation support technology in case of water cutoff disaster
- Usefulness of Wi-SUN for large-scale disasters on remote islands
- Proposal of water supply method using advanced technology

(Note): In 2018, when this exercise was conducted, a large foreign-flagged cargo ship collided with the only bridge connecting Suo-Oshima Town, where the school is located, to the mainland (the bridge shown with the Oshima Maru in Figure 1) and damaged the bridge. As a result, the water supply, one of the lifelines of the island, was cut off, and the bridge was closed to limited traffic, forcing the islanders to suffer for several months. Because of this accident, a study related to water supply due to the "water cutoff" that actually occurred as a disaster has been added to the PBL theme of this exercise. Although the project was designed to deal with the communication infrastructure following a power outage, the project encountered a disaster in a different way than envisioned, and the students had to tackle a practical issue.

(a) Experiment 1

(b) Experiment 2

(c) Collaborative experiments with the training ship Oshima Maru and Oshima Maru crew

Figure 7. Communication experiment by the training ship Oshima Maru (CEE phase 3)

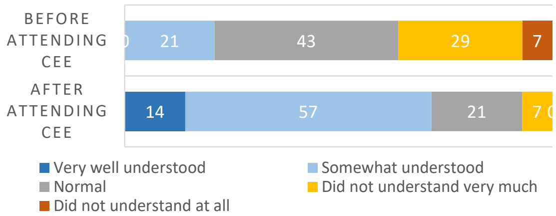
Figure 8. Presentation of PBL (AL) results (CEE phase 2)

CEE phase 3 [Practical exercise]: In conjunction with CEE phase 2, a practical exercise using the training ship Oshima Maru will be is conducted.

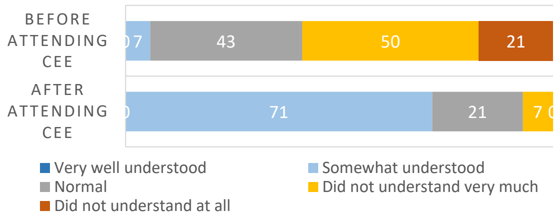
In FY2018, we conducted a communication demonstration experiment on the training ship in cooperation with the local government. The experiment was conducted using the training ship Oshima Maru, the rooftop of Suo-Oshima Town Hall, and the rooftop of Suo-Oshima Town Meishin Elementary School as relay stations, and was a very useful communication demonstration experiment, including the collection of practical data.

Figure 7 shows the CEE phase 3 communication experiment conducted in collaboration with the Oshima Maru crew using the training ship Oshima Maru. Figure 8 shows a presentation of the results of the PBL (AL) tasks set by each group in CEE phase 2.

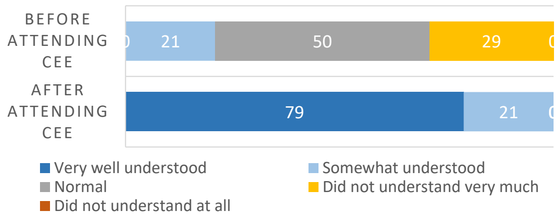
Results: Figure 10 shows the results of a questionnaire measuring the effectiveness of learning through this exercise (project). The results are based on a comparison of the questionnaires before and after CEE. The results show that the students' understanding of advanced technology has improved in all areas. In addition, many students responded that they "understood very well" in the "disaster countermeasures" section of the field training using the training ship Oshima Maru.



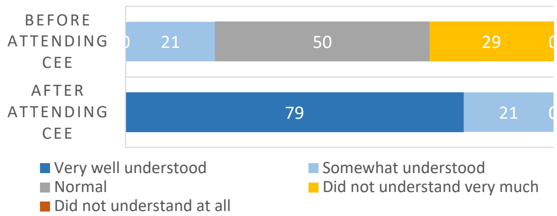
(a) About IoT [%]



(b) About AI [%]



(c) About robotics [%]



(d) About disaster countermeasures [%]

Figure 9. Learning effectiveness questionnaire

The following comments were obtained from the students through this exercise in the FY2018 report.

- It was a very good experience for me because it was a more practical class, which I have not had in my previous classes.
- I had only vague ideas about disaster countermeasures, but now I can think more concretely when I actually think about and implement the system by myself. In addition, this time I thought of a system based on an actual water outage, but if I have another opportunity like this, I would like to think of a system based on an earthquake, etc.
- The experience of the water outage in Suo-Oshima-cho that occurred during the period of the exercise made me understand more deeply the importance of the communication network in times of disaster, and I was able to work on this exercise.

Furthermore, based on the content conducted in this exercise, we applied to the IoT Application Category of the 2019 KOSEN Wireless IoT Technology Demonstration Contest. The KOSEN Wireless IoT Technology Demonstration Contest invites ideas for utilizing technologies that take advantage of the characteristics of the 5th generation mobile communication system (5G) and wireless IoT to technical colleges (students and faculty) nationwide. Figure 10 shows a poster with an overview. As a result, the project received the Minister of Internal Affairs and Communications Award (Grand Prize) in recognition of its implementation.

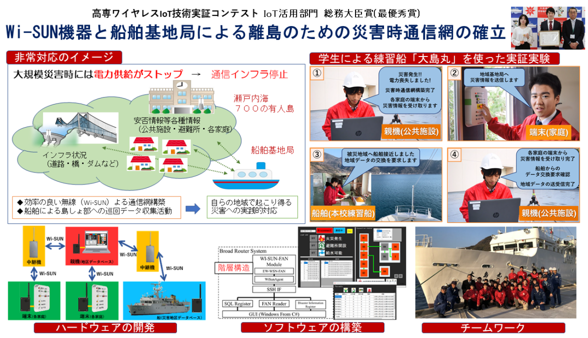


Figure 10. Overview of the application for the 2019 KOSEN Wireless IoT Technology Demonstration Contest (in Japanese)

Conclusions

This report describes our college's efforts to utilize the training ship Oshima Maru for engineering education. We believe that the experience of collaboration with other fields, which cannot be obtained in engineering education, will contribute to the diversity of students' viewpoints as engineers in the future.

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PRACTICAL DATA SCIENCE EDUCATION FOR KOSEN STUDENTS USING THE ANALYSIS OF SATELLITE SENSOR DATA

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Abstract

The purpose of this study was to develop a data science training program for educational curriculum improvement in the National Institute of Technology (KOSEN). The data science curriculum focuses on the key skills "Research Design", "Data Engineering", "Machine Learning", "Mining and Exploring", "Data Visualization", "Ethics and Privacy", "Statistical Analysis" and "Communicating Results". To cultivate data science skills, we conducted collaborative research with the Kyushu Institute of Technology, which involved practical training on some of the skills. To achieve this purpose, we set three objectives for teaching data science: the first is to express the outputs of analysis as clear sentences; the second is to introduce new and/or alternate coding methods; and the third is to use real datasets. In this study, time series data obtained by SWARM satellites were used as training, validation and test datasets for constructing a training model using convolutional neural and long short-term memory networks. Students were engaged in practical application of machine learning for the satellite data. The results were discussed in terms of their effectiveness for automatic detection of periodic fluctuations in the geomagnetic field. The discussion was appropriately guided by faculty members of the Kyushu Institute of Technology to help provide an effective understanding of how to evaluate research results. Our results indicate that processing, analysing, and visualizing satellite sensor data are effective for data science training in the KOSEN educational curriculum. We constructed an experiment based on teaching materials produced from the results of this research. Now, more students can be given the opportunity to acquire knowledge and skills related to data science. The data science education in our school will continue with improved educational materials for data science in the future.

Keywords: *Data Science, Educational Curriculum for Advanced Course Students, Machine Learning*

Introduction

Because artificial intelligence plays a growing role in the science and technology sector, especially in the IT sector, the social demand for machine learning engineers has skyrocketed. In response to the rising demand for highly skilled human resources (including machine learning engineers) in recent years, the Japanese education system has been improved by including data science curriculums in compulsory education (MEXT, 2019).

However, current conditions in higher education in Japan have been criticized for not producing enough machine learning engineers (e.g., Mizuho Information & Research Institute, Inc., 2019; Yamanaka and Suzuki, 2020). At present, fostering highly skilled human resources, including machine learning engineers, is becoming an urgent issue for institutions of higher education.

The purpose of this study was to provide practical training on data science. We considered what the best way to learn data science is. According to the Master of Information and Data Science program provided by the UC Berkeley School of Information, the data science curriculum focuses on the following key skills: "Research Design", "Data Engineering", "Machine Learning", "Mining and Exploring", "Data Visualization", "Ethics and Privacy", "Statistical Analysis" and "Communicating Results".

We chose students' research topics in earth and planetary sciences because large amounts of open data are available and suitable for data science research. The above-stated skills are provided through these activities. This course is composed of Thesis Research III (Apr. ~ Aug.) and Thesis Research IV (Sep. ~ Feb.) and is required for advanced engineering school students.

We note the following important points for teaching data science and putting them into practice:

1. Express outputs of analysis as clear sentences.
2. Introduce new and/or alternate coding methods.
3. Use real datasets.

Teaching materials for the data science education were developed through the above research activity. Then, an experiment was conducted for students in the Information and Systems Course with these materials. In this experiment, students could choose from a variety

of data sets, clean (normalize) data, construct data sets for machine learning and optimize the data to improve the accuracy of the machine learning model. Then we could construct an experiment for more students to practice the skills considered essential for data science.

Methods

In this study, we designed research activities to enable students to acquire the skills required for data science as described in this section.

Research Design: At the beginning of our program, we introduced how to design a research study. The introduction consisted of explanations of three main types of designs for research (data collection, measurement and analysis), the essential elements (accurate purpose statement, techniques to be implemented for collecting and analysing research, the method applied for analysing collected details, type of research methodology, probable objections to the research, settings for the research study, timeline and measurement of analysis) and four key characteristics of a design (neutrality, reliability, validity and generalization). Then, the students designed their own research themes on these perspectives. "Research Design" provided through these activities allowed the students to set up their studies for success. During these activities, we had a meeting with the faculty members of the Center for Nanosatellite Testing (CeNT) established by the Kyushu Institute of Technology. CeNT consists of facilities specialized in the space environmental testing for nanosatellites. The Kyushu Institute of Technology promotes joint studies between itself and the National Institute of Technology (KOSEN). This is because the Kyushu Institute of Technology seeks students with high academic ability. Students transferred from KOSEN will enrol in the Kyushu Institute of Technology from the third year. In addition, we needed real datasets available as teaching material for data science education and considered the satellite data to be suitable as teaching material. Then, we conducted joint research with the Kyushu Institute of Technology and looked for better solutions while designing the research.

Data Engineering: Next, we worked on "Data Engineering", which may be considered synonymous with "Feature Engineering". Geomagnetic observation data obtained from the SWARM satellite constellation are time-series data. The absolute value and the fluctuation range of the geomagnetic field data are changeable. Then we normalized, standardized and reshaped the magnetic field data for construction of machine-learning datasets. In other words, the satellite data are good educational material for learning data science skills.

Machine Learning: In this study, spectrograms and time series data of the geomagnetic field were treated as training, validation and test datasets for constructing a training model using convolutional neural networks (CNNs) and long short-term memory networks (LSTM). This method is a new approach for extracting geomagnetic pulsations. Then, we divided the training datasets and the test datasets. In this case, we assumed that we can use a model based on 1D CNN-LSTM or a combination of models. We then proposed a method for acquiring spectrograms and provided an example of pre-processing of time series data for a group of training datasets needed in this case. The students learned practical time series analysis. Then, we established that these activities provided a chance to learn "Machine Learning" skills.

Data Visualization: We used three motivating examples of the SWARM satellite data and a data visualization package for the programming language Python. We started with simple datasets and then graduated to case studies on electromagnetic ion cyclotron waves. Mistakes, biases, systematic errors and other unexpected problems often lead to data that should be handled with care. The students learned the difficulty of noticing mistakes in a dataset. The students acquired the "Data Visualization" skill through these activities.

Communicating Results: Data visualization provides a powerful way to communicate data-driven findings, motivate analyses and detect flaws. These activities gave the students the skills we need to leverage data to reveal valuable insights. The students used statistics to gather, review, analyse and draw conclusions from the data, as well as apply quantified mathematical models to appropriate variables. Regarding the obtained results, opinions were exchanged with the staff of the Kyushu Institute of Technology on improvement of analysis methods and data cleaning methods, and judgment of an appropriate machine-learning model. The skill "Communicating Results" was provided through these activities.

To achieve the goals, we set the following objectives to devise methods for teaching data science and to put the methods into practice:

1. <u>Express outputs of analysis as clear sentences</u>. We paid attention to significations of numerical outputs of analysis. To reveal the meaning of our data, we went back to the data science questions and stated the answers clearly.
2. <u>Introduce new and/or alternate coding methods</u>. We wrote and taught codes in steps, and showcased variations to our code.
3. <u>Use real datasets</u>. There are many places to acquire open data. We used open data about the real world that the students could treat as a variety of data sets beyond the research activities.

Results and Discussion

In this study, cooperative research with the Kyushu Institute of Technology was carried out. Then, we applied machine learning to the time series data obtained from SWARM satellites. Nielsen (2019) offers a well-rounded introduction to time series for data scientists, software engineers and researchers. The data

analysis was performed in accordance with Nielsen (2019).

This study aimed to develop a satellite system to discriminate specific natural phenomena in a future mission. The observation data of the SWARM satellites were assumed as magnetic field data observed by a CubeSat, and the model was trained. The SWARM satellites are scientific satellites for measuring the earth's magnetic field and were launched in 2013 by ESA (Friis-Christensen et al., 2007). The magnetic field data observed by SWARM are available to the public and can be acquired via the Internet. The experimental procedure of this study was as follows:

1. Extract the observation data of SWARM satellites at fixed time intervals and divide them into two groups depending on whether geomagnetic pulsations occurred or not. The data extraction interval was determined by the target period of geomagnetic pulsations.
2. Construct a data set from a set of extracted data.
3. Input data into each model and train the models.
4. Compare and verify the accuracy rate of each model.
5. Optimize the models for satellite implementation.

This study enabled us to automatically detect geomagnetic pulsations on the satellite orbit, and to selectively download the data when geomagnetic pulsations occur.

The estimation model consists of input layer (the magnetic field in three dimension) the intermediate layer of the LSTM and fully connected layer that outputs classify the occurrence of EMIC wave. LSTM used data up to 10 minute ago as past data. An overview of a sample of the constructed model in this study is shown in Figure 1.

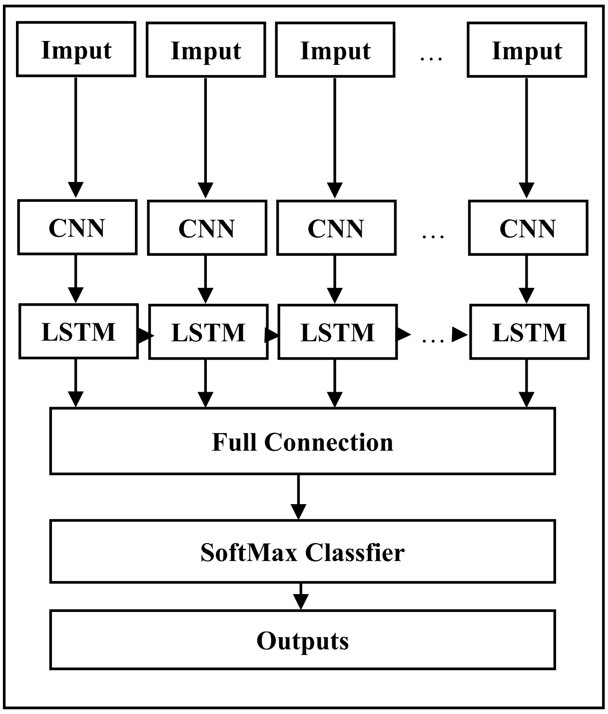

Figure 1: Structure of CNN & LSTM network

The advanced-course students were able to learn the skills necessary for data science. Table 1 summarizes the implementation status for each skill. In addition, the overall student performance improved. The overall improvement of data science education within the educational curriculum for advanced-course students will build competencies and skills among the students. In our experiments, we could offer learning opportunities for only a few students.

In this study, some key skills could not be implemented with the applied research activities. We still need to implement learning of these skills in various courses.

Mining and Exploring: Data mining is a process of extracting useful information, patterns and trends from raw data. In this study, we determined that the absolute values and the fluctuation range of the geomagnetic field data are changeable. Then we normalized, standardized and reshaped the magnetic field data for construction of the machine learning dataset. Data mining processes have different types of services, such as text mining, web mining, audio mining, video mining, pictorial data mining and social network data mining. We will implement a training program on "Mining and Exploring" skills in the future.

Data Ethics and Privacy: In the field of data science, there are potential effects of algorithmic decision-making and bias, with reports of manipulation of news feeds affecting elections, discriminatory advertisements or search engine results and companies using big data to subvert regulators. The aims of this module are to introduce students to the various ethical dilemmas that are arising in our "data-driven society", with an emphasis on the ethics of using data science, data protection and privacy, and algorithmic governance. We plant to implement a training program on "*Data Ethics and Privacy*" skills in the future.

Table 1: Implementation status of the key skills for data science

Skill Name	Status
Research Design	Implemented
Data Engineering	Implemented
Machine Learning	Implemented
Mining and Exploring	Not Implemented
Data Visualization	Implemented
Ethics and Privacy	Not Implemented
Statistical Analysis	Implemented
Communicating Results	Implemented

Conclusions

This paper addresses only a few case studies. We must continue to evaluate the effects of research activities on data science education. Another achievement of the study was the development of teaching materials. We constructed an experiment based on teaching materials produced from the results of this research. The data science education in our school will

continue with improved educational materials in the future.

Acknowledgements

This work was done in the framework of joint studies between the Kyushu Institute of Technology and KOSEN.

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CBT tests for conducting face-to-face and online in KOSEN-KMITL

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Abstract

The KOSEN-KMITL, the first Japanese style KOSEN in Thailand, was established in May 2019 in King Mongkut's Institute of Technology Ladkrabang (KMITL). Furthermore, Computer Engineering Department was established in May 2021.

The Computer Engineering Department specialise for not only computer science but also cyber security area. However, the department has only 1st grade students. Therefore, they learn basically computer engineering technologies for example programming and digital circuit.

Recently, pandemic attacked the world. Also, there is no exception in Thailand. Hence, KOSEN-KMITL also must deal with the online examination. The classes are held face-to-face, and the test was conducted online because the spread of the infection progressed faster than expected. Therefore, the computer engineering department prepare the examinations that can be used both online and face-to-face. The department prepare computer-based tests (CBT). Basically, All KOSEN-KMITL students bring your own device (BYOD). Hence, faculties of the department focus on CBT. However, the digital circuit is difficult to prepare CBT because it has drawn graphs, equations, and tables. Furthermore, programming is difficult to take the examination on CBT because faculties difficult to estimate students' flexible answers. This article explains how to prepare CBTs especially fundamental of computer science area. Furthermore, we discuss compare face-to-face and online test results in KOSEN-KMITL.

Keywords: Online examination for Computer Course, CBT, BYOD

Introduction

Ensuring students' learning opportunities through online learning during pandemics is very important. There has been a debate about how online learning can ensure the quality of students' self-studies. (M' hammed Abdous, 2009) suggests quality assurance for e-learning. However, due to the impact of COVID-19, online learning is moving from a self-learning component to learning through collaborative efforts between teachers and students. (Margarita Gocheva, Nikolay Kasakliev, Elena Somova, 2021), the form of online teaching has changed significantly.

Even in the KOSEN-KMITL, the period of transition between face-to-face classes, online classes, and hybrid classes conducted partly face-to-face and partly online has continued.

In such circumstances, it was necessary to create a task for the final examination. The final examination was initially planned to be conducted on-site; however, the worsening infection situation forced it to be conducted online.

The Computer Department of KOSEN-KMITL provided lessons using "bring your own device" (BYOD) from the beginning and prepared for the test using Computer-Based Test (CBT) so that it could be handled either online or on-site, considering the unpredictable infection situation.

In this paper, we present some examples of tests on information subjects prepared by the Computer Department of KOSEn-KMITL, especially tests on digital circuits and programming.

Face-to- face material

Since face-to-face testing was possible in the intermediate testing of digital circuits, paper-based testing, which was an old method, was conducted.

Because of the characteristics of digital circuit subjects, it was necessary to perform test items that were not suitable for CBT, such as drawing circuit diagrams and creating truth tables. Fig. 1 shows an example of the intermediate test questions.

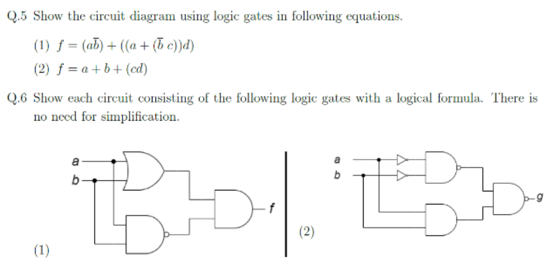

Figure 1 Digital Circuit mid-term exam (On site)

The students were conducting on-site classes, and because the classes were not conducted on-line, they

were able to take the examination and answer the examination with the same feeling as usual.

Online material for Digital Circuit

For the reasons mentioned above, end-of-term exams were conducted online, from the outset, CBT was designed to allow online and on-site testing.

KOSEN-KMITL provided online classes using Microsoft Teams and was able to use Google Classroom as a Learning Management System (LMS), which is probably a standard system configuration. It is believed that there are some technical colleges in Japan that have prepared similar environments.

Therefore, we decided to use Google Forms to create the problem as following two reasons. First, it's a good fit with Google Classroom and Second, it's easy to create choice problems that Microsoft Teams didn't have at the time.

Fig. 2 shows an example of a problem to obtain a Boolean expression from a Karnaugh map. By providing multiple expressions and an option that does not apply to either of the above, the range of students' thinking is widened. Also, as a characteristic of the problem, the Karnaugh map is a method to obtain an answer by drawing on a table, so how to draw is a key. Therefore, the Karnaugh ot map is displayed on the test screen, and students are allowed to enter the examination while taking notes on a memo pad at hand.

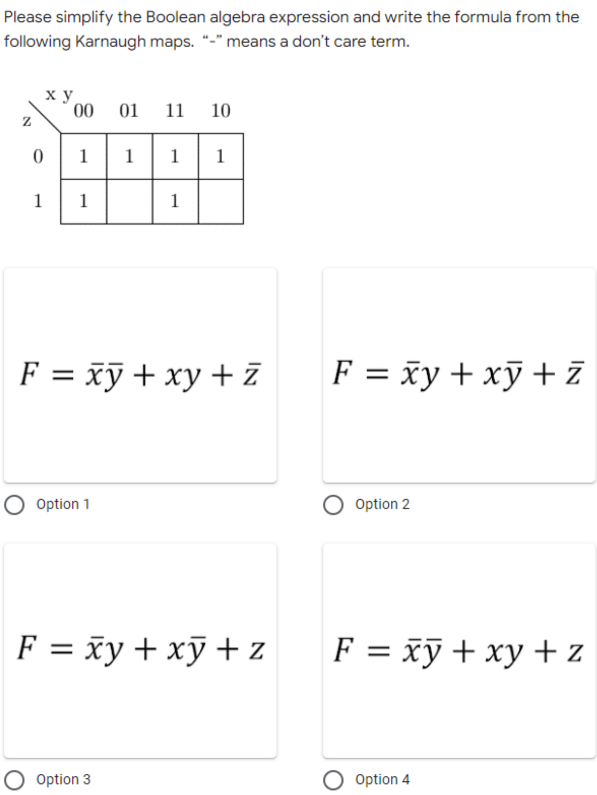

Figure 2 Truth table to Boolean algebra

FIG. 3 shows an example of the Karnaugh map drawing problem.

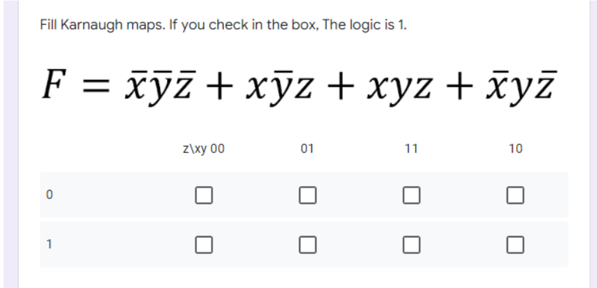

Figure 3 Draw the K-Map

Since it is also difficult to draw the table online, we devised it. Specifically, we used a check column that can be represented by a matrix. We instructed that the check means 1 and the blank means 0. We prepared the answer column of the matrix so that it looks like a Karnaugh map.

Fig. 4 shows an example of the truth table drawing problem, which uses the same method as the Karnaugh Map described above to query the check column of the matrix so that it looks like a truth table.

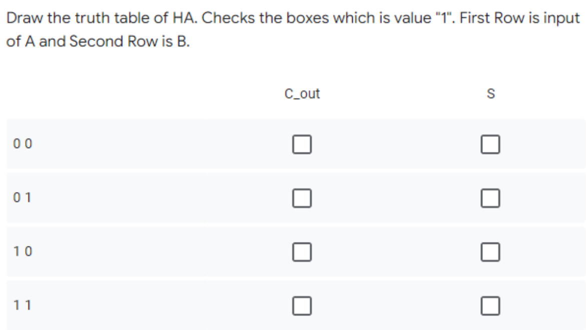

Figure 4 Truth table

We could not find an optimal solution for the problem of circuit drawing, and Fig. 5 shows an example of the problem of circuit drawing.

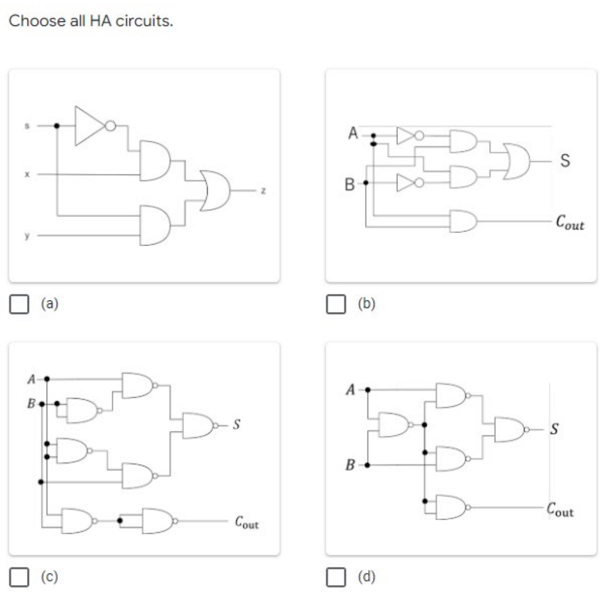

Figure 5 Choose circuit diagram

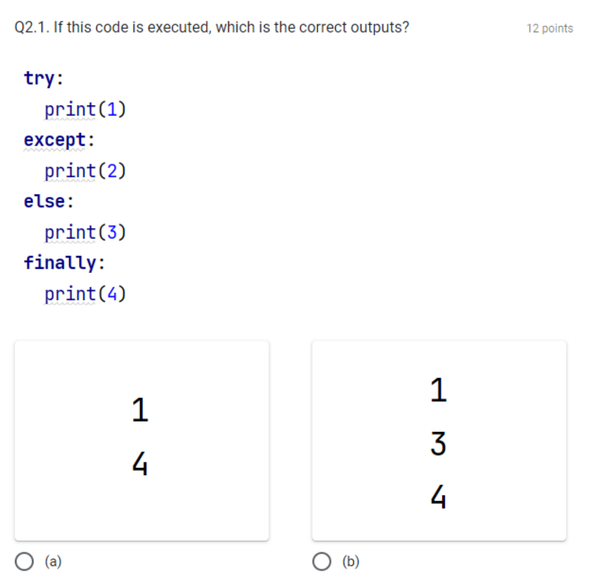

Figure 6 estimate output

For this type of problem, we tried to avoid narrowing the range of students' thinking by providing the answer that there is no solution. In addition, by preparing multiple circuit diagrams in advance, it is possible to ask the students' knowledge. Since all the diagrams prepared are circuit diagrams that have been handled in the class, it is possible to confirm that the students' knowledge has been established.

On the other hand, it cannot be denied that this method is inappropriate as a question of the output of students, especially since the pattern is limited, it is difficult to determine whether students truly understand it.

Online material for Programming

Online testing is one of the most difficult subjects because Programming allows you to write your own free answers. In order to solve this problem, we created a code reordering problem and a problem predicting output results. Figure 6 shows an example of a problem predicting output results.

In order to predict the output result from the code, knowledge of programming is essential, so it is an indicator of how much you have acquired the language. On the other hand, we created a problem to select a blank code from the output result.

Results and Discussion

The test results show that students who did poorly in the mid-term exam at the digital circuit improved their grades for three reasons There are three possible reasons for this. It was shown that it was suitable for the online test. The difficulty of the test was lowered by narrowing the options. The difficulty was overcome by the effort of the person. In any case, we think that the test is not a factor to deny CBT because it should measure how much knowledge the student acquired.

As a secondary effect, it was also confirmed that scoring became easier and more accurate. Although double-and-triple checking is the basic method, I realized that the speed of scoring is dramatically faster than that of manual checking.

Conclusions

In this paper, we present a case study of CBT using BYOD in a pandemic trial. While we felt the convenience of CBT, we still had the problem of limiting the range of responses. However, it was a very significant result to be able to do the same test in an online test. Finally, we hope that the test we created will help.

Acknowledgements

You may acknowledge (when appropriate) the organisations who have funded or extended their facilities for doing the work.

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INTEGRATION OF PROJECT-BASED LEARNING IN POLYTECHNIC EDUCATION

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Abstract

Project-based learning provides opportunities for learners to apply knowledge and skills that they have learned to answer driving question(s) based on authentic problems or projects provided by the industry partners. Literature has shown that project-based learning develops learners to be better problem solvers and high-order thinkers, as well as improves learners' engagement. Hence, project-based learning has been adopted by School of Engineering (SEG), Nanyang Polytechnic (NYP), Singapore as one of the teaching methods to further improve the learner and teacher engagement, develop learner's critical core skills and close the learner's achievement gap.

This paper explains how the project-based learning was systematically introduced, integrated, and contextualized into the project modules offered by different diploma courses. The processes, classroom activities, facilitation techniques and tools that are used in designing and delivering the project modules will also be discussed. The results on the effectiveness in implementing project-based learning are measured through the perceptions of the learners. The findings showed most of the learners felt engaged and had enough opportunities to practice their soft skills. However, lesser than targeted number of learners felt confident in completing their project work. The last part of the paper highlights the challenges faced and provides improvement to further fine-tune and streamline the on-going implementation effort.

Keywords:

Project-based learning, active learning, facilitation technique, project design elements, project teaching practices.

Introduction

Project-based learning is a holistic teaching method in which learners gain knowledge and skills by investigating and responding to a complex question, problem, challenge, or project. It combines creativity with the essential skills needed in the workplace. It also provides opportunities for learners to apply knowledge and skills that they have learned to answer driving question(s) based on authentic problems provided by the industry partners or develop solutions based on the project requirements specified by the industry partners. It has become popular and widely adopted worldwide by many schools, colleges and even universities. Many research and studies have claimed to have benefited from the implementation of project-based learning (Larmer, Mergendoller & Boss, 2015). In particular, project-based learning provides several positive learning outcomes for learners. These include

- Better problem solvers and high-order thinkers (Pinho-Lopes & Macedo, 2014)
- Better learning attitudes and "comparable or better" performance on content knowledge (Parker et al., 2011)
- Improved learner engagement as there is significant relation between project-based learning and collaborative learning, disciplinary subject learning, iterative learning, and authentic learning (Almulla, 2020).

While project-based learning is not new to SEG, most of the project modules are designed with more emphasis on how learners can apply the knowledge and skills learned in other academic modules in the project than critical core skills such as communication skills, collaboration, critical thinking, and teamwork. Lessons deliveries in each of these project modules can be very different and thus the feedback received from learners varied in terms of learner's engagement, their perception of the usefulness of the project modules, as well as their interest and confidence in solving the problems.

In 2019, a team was set up to conduct a deeper study on the applicability and suitability of implementing the proven research-based Gold Standard project-based learning project design and teaching method by Buck Institute in SEG, NYP. Upon evaluation, the team was subsequently tasked to drive the implementation of Gold Standard project-based learning in SEG to achieve the following objectives:

1. Further improve the learner and teacher engagement
2. Develop learner's critical core skills (aka soft skills)

3. Close the learner's achievement gap (aka their perceived interest and usefulness of doing the project, as well as their confidence in completing the project)

In this paper, we will first describe the Gold Standard project design elements, teaching practices and lesson delivery phases developed by Buck Institute, followed by describing how SEG, NYP contextualized and integrated these Gold Standards into the project modules, as well as the new techniques and tools that are developed for lecturers who are involved in delivering the project modules. In the subsequent sections of this paper, we will share the implementation approach and discuss the results and findings from the pilot studies of two project modules in 2021. The paper will end with describing the challenges faced, recommended areas of improvement and plans to implement project-based learning in all the diplomas in SEG, NYP.

Gold Standard Project-based Learning by Buck Institute

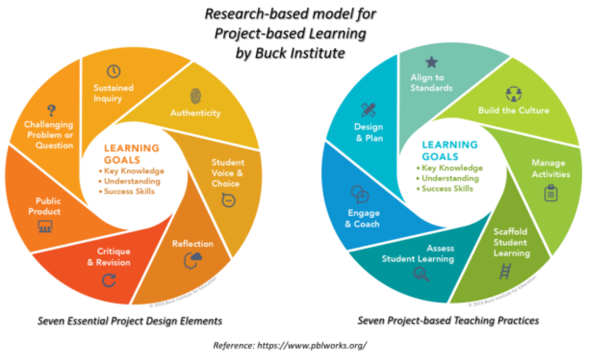

Figure 1: Research-based module for Project-based learning by Buck Institute

Buck Institute developed a comprehensive, research-based model for project-based learning as shown in Figure 1 which can be served as a Gold Standard to help lecturers, schools, and organizations to measure, calibrate, and improve their implementation.

The Gold Standard project-based learning consists of three parts. Firstly, it emphasizes not only the technical knowledge and understanding but also the success skills such as critical thinking, collaborations, and communication. Secondly, it guides the design of the project by providing a set of seven essential project design elements to design a successful project. Lastly, it has a set of seven teaching practices to guide lecturers who are practising project-based learning. However, these seven project-based teaching practices will not be discussed in detail in this paper.

Seven Essential Project Design Elements

The Gold Standard project-based learning suggests that there are seven essential project design elements that are necessary to create a successful project that maximizes learning and engagement. As shown in Figure 1, these essential elements are *Challenging Problem or Question*, *Sustained Inquiry*, *Authenticity*, *Student Voice & Choice*, *Reflection*, *Critique & Revision*, and *Public Product* (Larmer, Mergendoller & Boss, 2015).

Challenging Problem or Question encourages project idea to be framed into a challenging problem or driving question to make learning more meaningful for learners. Learners can apply knowledge gained to solve a problem or answer a question that matters to them.

Sustained Inquiry refers to an in-depth iterative inquiry process to allow learners to ask questions, find resources to help answer them, then ask deeper questions until a solution is developed.

Authenticity emphasizes on the concept of how "real world" is the learning experience of the project. It can be in the form of context, real world processes, tasks, and tools. An authentic learning experience can increase learners' motivation in learning.

Student Voice & Choice calls for learners to voice their ideas and make choices throughout the development of the project. The project should also allow learners to have their inputs and control over the project to create a sense of ownership in them.

Reflection covers how learners could learn from their project through reflecting on the experience they have gone through. Therefore, reflection activities should be included throughout the project duration.

Critique & Revision promotes the quality of the project through constant critique, feedback, revision and improvement of the project. It emphasizes on checkpoints, where learners receive critiques, feedback from their peers, lecturers, or subject experts, they will then examine the quality of their projects, revise and improve them.

Lastly, *Public Product* is about bringing the project to the public. It provides an opportunity for learners to share their project with an audience beyond the classroom. Through the sharing, learners will feel a sense of pride and satisfaction on their projects.

Seven Project-based Teaching Practices

The Gold Standard project-based learning also suggested seven project-based teaching practices. As shown in Figure 1 too, these practices are Design & Plan, Align to Standard, Build the Culture, Manage Activities, Scaffold Student Learning, Assess Student Learning and Engage and Coach (Boss & Larmer, 2018).

Project-based Learning Lesson Delivery Phases

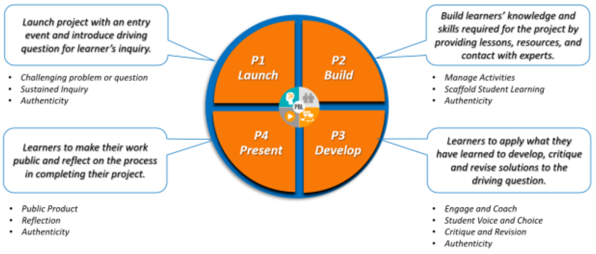

Figure 2: Project-based Learning Lesson Delivery Phases

The Gold Standard project-based learning suggests that the project-based learning lesson delivery of a project can be broadly divided into four phases, namely *Launch*, *Build*, *Develop* and *Present* phases as shown in Figure 2 (Larmer, Mergendoller & Boss, 2015). The seven essential project design elements and some of the teaching practices were incorporated into these four phases.

In the *Launch* phase, the project is launched with an entry event and the driving question is introduced to the learners for further inquiry purpose. While designing the delivery of this phase, project design elements such as *Challenging Problem or Question* and *Sustained Inquiry* should be considered. This will help to make sure that the project we have designed is challenging enough that could sustain the inquiry of the learners throughout the project. The objective of this phase is to make sure the learners are clear about what they need to learn and do for their project.

The *Build* phase is meant for learners to build their knowledge and skills required for their project. This can be done by providing lessons, resources, and even contact with experts. In this phase, teaching practices such as *Manage Activities* and *Scaffold Learner Learning* should be considered while preparing lesson schedule and teaching materials. This is to ensure that manageable, sufficient, scaffolded activities are provided to help learners build their knowledge and skills for their projects.

After the learners have equipped themselves with the necessary knowledge and skills, the *Develop* phase can kick in for learners to start applying what they have learned to develop, critique, and revise possible solutions for their project. In this phase, teaching practices and project design elements such as *Engage and Coach* and *Student Voice & Choice*, serve as a guide to engage learners, to coach them continuously on their projects if needed and to encourage them to speak up and make decision within their team for their projects. The project design element on *Critique and Revision* can also be infused through the activity in this phase for learners to learn how to critique others' work professionally and to accept critique from peers in order to revise their projects in achieving higher standard of project prototype.

The last phase, which is the *Present* phase, is when learners make their work public and reflect on the process in completing the project. This is also the phase in which the two project design elements of *Public Product* and *Reflection* can be infused.

The last element, *Authenticity* does not specifically fall within any of the phases but rather it should be infused implicitly or explicitly throughout the implementation to create an authentic project learning experience for learners.

Contextualization of Gold Standard Project-based Learning in SEG, NYP

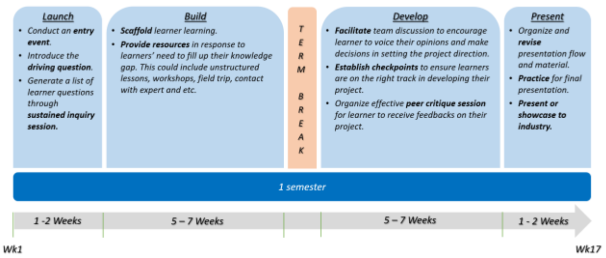

Figure 3: Project-based Learning Lesson Delivery Phases

The Gold Standard project-based learning delivery suggested that each phase should consist of a whole suite of recommended activities to be done to achieve the desired outcome.

This represents a significant change for lecturers and learners in terms of the teaching and learning practices. To reduce the resistance to new changes, contextualization effort is needed to adapt activities that are deemed to be more manageable for both the lecturers and learners.

Figure 3 shows a typical sixty to ninety hours project module in SEG and how the project design elements, teaching practices and learning activities are integrated into a project-based learning module. Contextualization effort here would mean selecting an adequate amount of important and yet manageable activities to be carried out in each project lesson delivery phase to achieve the outcomes.

For the *Launch* phase, entry event, introduction of driving questions and sustained inquiry session are the 3 activities to be carried out within the first 2 weeks for learners to get into the mood of starting their projects.

For the *Build* phase, a duration of five to seven weeks is recommended for learners to build up their knowledge and skills that are required for their projects. Structured or unstructured lesson can be conducted to scaffold learners learning. Activities such as field trip, workshop,

talk by expert were recommended to be put in place as well.

After two weeks term break, the learners will proceed to the *Develop* phase to start developing their projects and a duration of five to seven weeks is recommended for learners to complete their project. In this phase, lecturers are expected to facilitate learners' team discussion, establish checkpoints to ensure learners are on the right track in developing their projects. An effective peer critique session should be organized for learners to receive feedback for their projects for further improvement or revision.

The last *Present* phase, learners are given one to two weeks to prepare and design their slides for their public presentation. Lecturers are recommended to review their slides and conduct practise sessions before the final presentation to the public.

Techniques, Tool and Assessment Rubrics Introduced for Project-based Learning in SEG, NYP

As part of the contextualization effort, some techniques and tools have been introduced to help lecturers to manage the changes in teaching and learning practices in project-based learning module.

3Ps Inquiry Facilitation Technique

Question Formulation Technique (QFT) introduced by Right Question Institute is a widely adopted technique in higher education engineering courses and it shows a positive impact on learning (Dera, Borgaonkar, Scharf & Sodhi, 2020)**.** Bearing in mind that lecturers often find it challenging to facilitate and guide learners in asking questions effectively during the sustain inquiry activity under the *Launch* phase, designing a simpler inquiry technique which is easy to remember and applied by all lecturers is desired. Hence, a 3Ps Inquiry Facilitation Technique was designed based on the QFT as shown in Figure 4.

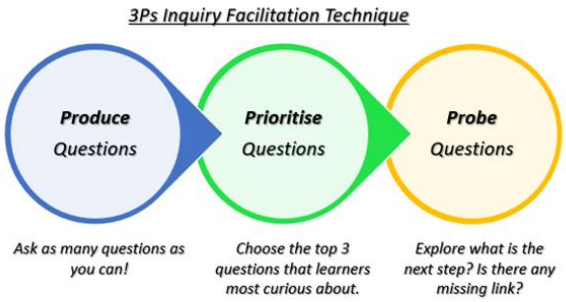

Figure 4: 3Ps Inquiry Facilitation Technique

The first P is *Produce Questions*, where lecturer encourages learners to ask or to produce as many questions as possible. They are not to judge or answer any questions, not to change any statement or change close-ended questions to open-ended questions, and lastly, they are to write down every question exactly as it is stated.

The second P is to *Prioritise Questions*. Learners are asked to prioritise the top three questions which they are most curious about. However, the number "three" is not a magic number, the lecturer can ask learners to prioritise X number of questions depending on the needs of the project and key content knowledge and skills which the lecturer would like the learners to investigate further.

The third and last P is *Probe Questions*. The lecturer needs to read through the questions produced by the learners and examine whether there are any missing links to the key content knowledge and skills that the learners should learn in the project. If there are missing links, the facilitator should probe more questions to help learners to connect the key content knowledge and skills at this stage.

3As and 3Rs Classroom Facilitation Technique

Engage and Coach is one of the teaching practices recommended by Gold Standard project-based learning implementation. Lecturers play an important role in engaging and coaching the learners in the project-based learning classroom that involves a lot of small group discussion, inquiry and brainstorming with or among the learners. To support and provide some simple and easy to remember classroom facilitation technique for lecturers to practice, the 3As and 3Rs classroom facilitation technique was designed. 3As stand for *Approach*, *Assist* and *Aware* while 3Rs stand for *Recall*, *Reiterate* and *Relate* as shown in Figure 5.

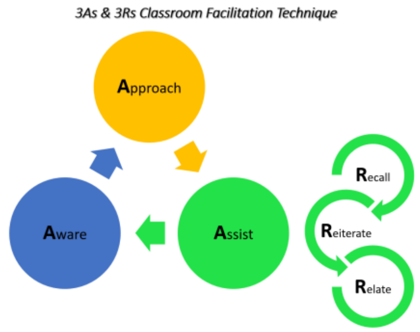

Figure 5: The 3As and 3Rs Classroom Facilitation Technique

The first A is *Approach* where lecturers are encouraged to be more proactive to approach learners with the aims of checking learners' understanding and keeping them engaged with the task on hand. As most of our learners are quiet and shy, the *Approach* step is crucial to engage them in conversations, inspire deeper and higher order thinking, and promote learner-to-learner interaction. This in turn creates opportunities for learners to analyse their thoughts and evaluate their peers' perspective to promote collaborative learning.

The second A is *Assist*, which means to provide some form of assistance to the learners if needed after approaching them. Assistance can be rendered to learners in two different forms depending on the needs of the learners. For fast learners, assistance can be in the form of providing them with constructive feedback on their project. The intent is to stretch them further by getting them to continue enhancing or improving their project work. For slow learners, assistance should be rendered in the form of providing them with guidance.

To better assist learners in applying their prior knowledge in the project, a structured 3Rs process was introduced in guiding the learners. 3Rs stand for Recall, Reiterate and Relate. Recall is to help learners recall their prior knowledge on a specific concept or method learned. Reiterate is to explain once again the concept or method the learners learned before. This is to help them refresh and reinforce their memory on the knowledge that they have learned. Lastly, Relate is to help learners connect the knowledge learned to their project.

The last A is *Aware*, which lecturers are encouraged to deliberately make learners aware and reflect on how they apply their knowledge learned into their project. Reflection is an ongoing process, and it is an important part of project-based learning as it helps learners to revise, improve and integrate new ideas into their existing work.

Peer Evaluation Tool

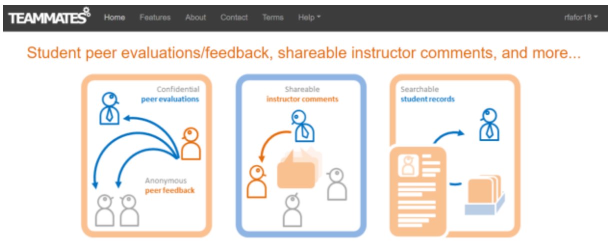

Figure 6: TEAMMATES Peer Evaluation Tool

One of the important project design elements in project-based learning is *Critique & Revision*. Peer evaluation is one of the methods used to allow learners to perform self-evaluation and receive feedback on their contributions that are evaluated by the team members. An online peer evaluation platform, TEAMMATES, was recommended to allow learners and lecturer to provide feedback as shown in Figure 6. The following questions were used to evaluate learners' soft skills in doing the project. Learners are asked to perform self-evaluation and evaluate their team members based on a Likert Scale of 1 to 10 where 1 is strongly disagree and 10 is strongly agree.

Q1	Please evaluate yourself and your teammates in terms of how well the team can work together.
Q2	Please evaluate yourself and your teammates in terms of the positive attitude towards challenges faced by the team.
Q3	Please evaluate yourself and your teammates in terms of the willingness to share information while working as a team.
Q4	Please evaluate yourself and your teammates in terms of respect for each other while working as a team.
Q5	Please allocate points to yourself and your teammates in terms of the contribution while working as a team.

Assessment

The project-based learning module requires learners to work individually as well as in teams. Thus, it is recommended to assign assessment weightings of either 50-50 or 40-60 to individual and group assessment tasks respectively. The intent is to prevent free rider in group work.

Standard rubrics have been designed for lecturers to assess not only the technical knowledge and skills, but also the soft skills such as creative thinking, decision making, problem solving, collaboration, and adaptability.

The Implementation Approach

The project-based learning implementation approach taken by SEG, NYP is to start small by creating a successful working model of Project-based learning practice before rolling out to all 11 diplomas in the school. Two project modules from two different diplomas were selected to adopt the contextualized project-based learning model and to implement it in the two modules for a semester. The following table shows the relevant information of the two selected project modules in 2021.

Table 1: Project Modules Information

Module Name	Module Hours	Abridged Module Synopsis
Polymers and Composites	90	Learners gain a foundation in the chemistry, physics and materials properties of polymer and composite materials. Learners will design and develop a composite for a specific application.
Connected System Design Project	90	Learners will apply their knowledge in electronics, computer, communications, and software programming into the development of a connected system. Learners will also be able to implement projects using open-source software and hardware.

Training sessions were provided for the two module leaders to re-design their project modules based on the contextualized Gold Standard project-based learning model and the delivery phases prior to the pilot run. Training sessions were also provided for the module tutors on the new techniques and tool required in delivering the lessons. In addition, the module leaders and tutors were able to consult the project-based learning team that was set up at school level to provide the necessary support and advice.

Results and Findings

The effectiveness of project-based learning implementation was evaluated in two broad areas. They are the impact of project-based learning on learners' motivation and the usefulness of the activities, methods, and tools used in the project-based learning lesson delivery. In this section, these two areas of evaluation will be discussed in detail.

<u>Impact on Learners' Motivation</u>

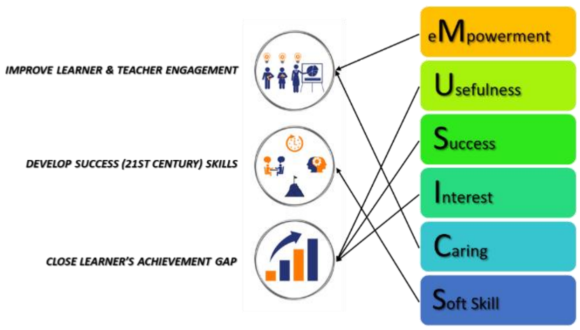

Figure 7: The Mapping of the MUSICS approach to the 3 Objectives of Project-based Learning Implementation in SEG

As mentioned earlier, the objectives behind contextualizing and integrating the Gold Standard project-based learning into SEG, NYP are to improve learner and teacher engagement, to develop critical core skills, and to close learners' achievement gap. To be able to measure these objectives, the MUSIC model of Motivation (Jones, 2009 & 2018) has been adopted as part of the survey instrument to measure the impact of project-based learning on learners' motivation in five dimensions, namely empowerment, usefulness, success, interest and caring. An additional dimension on soft skill is added into the survey instrument to meet all the three objectives. Figure 7 shows the mapping of the MUSICS survey instruments and the added dimension on soft skills to the three objectives of implementing project-based learning in SEG, NYP.

In total, there are thirty questions used for this evaluation (See Appendix 1). Twenty-six questions were from the MUSIC Model of Motivation and four questions were developed for soft skills (S), henceforth, we will name this instrument as MUSICS. Each of the questions is unique to the MUSICS dimensions, and the sequence of the questions in each dimension is randomised. The evaluation was administered to 109 learners at the end of the project modules, in which learners were asked to rate each question based on the scale of '1' to '6', '1' being strongly disagree and '6' being strongly agree.

From the response to the questionnaires, a score was obtained for each scale, by calculating the average of the values for the questions in the scales, as recommended by Jones (2018) in the MUSIC Model of Motivation.

Figures 8 and 9 show the result collected from the 83 learners from two selected project modules who responded to the MUSICS survey.

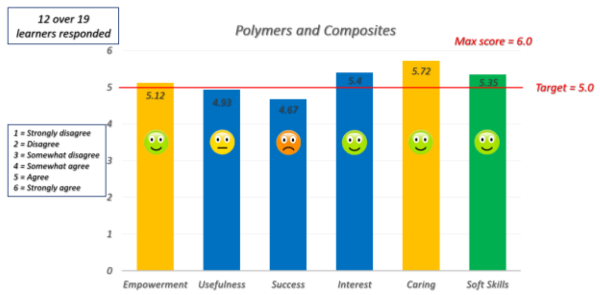

Figure 8: Survey Result for Project Module – Polymers and Composites

As shown in Figure 8, a target score of above 5 (agree and strongly agree) has been set by SEG as the reference target. Based on this reference target, it is observed that learners taking Polymers and Composites felt empowered (empowerment) and cared for (caring), and they were given ample of opportunities to practise their soft skills (soft skills). Learners were interested in the project (interest) and found it rather useful to them (usefulness). However, they felt they were less confident in their abilities to complete their projects (success).

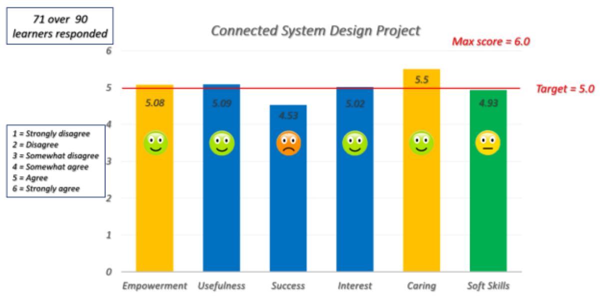

Figure 9: Survey Result for Project Module – Connected System Design Project

As for the result collected for Connected System Design Project as shown in Figure 9, learners felt empowered (empowerment) and cared for (caring) as well. But they needed more opportunities to practise their soft skills (soft skills). Learners were interested (interest) and found

the project useful to them (usefulness). However, they also felt less confident in their abilities to complete their projects (success).

From the result collected for both project modules, it seemed to imply that the implementation of project-based learning does help in improving the engagement level for lecturers and learners (empowerment and caring) and developing learners' soft skills (soft skills). It also seemed to imply that project-based learning does help to close learner's achievement gap in terms of the perceived interest (interest) and usefulness (usefulness) of doing a project but not in terms of their confidence in completing the project. Perhaps this self-reported lack of confidence could be attributed to the "cultural norm" in Singapore where learners are generally under-confident despite having consistent excellent performance internationally (Koh, 2021). This would require an in-depth study to explore how and why project-based learning appears not able to increase learners' confidence in completing the project.

Usefulness of the Activities, Methods, and Tools

Classroom activities, facilitation techniques and tools were recommended to aid lecturers in facilitating their project-based learning lesson delivery. To evaluate the process and its' usefulness, informal interviews were conducted to solicit feedback from module leaders and tutors. During the interview, their views on the usefulness and benefits of the activities, method and tools used, as well as the issues they faced in delivering their lessons were sought. In addition, areas for improvement were discussed during the interview.

From the interview, lecturers shared their observations on how the learners enhanced their skills such as project management and the ability to work independently through Project-based Learning. The lecturers also shared their joy in seeing their learners getting their Eureka moments working in teams to solve problems in new ways, recognising new opportunities to innovate and grow. However, some issues such as time management and the need for more staff training in facilitation and in using the techniques and tools were noted as areas for improvement.

Challenges and Recommendation for Improvement

It took around a year to contextualize the Gold Standard project-based learning model from Buck Institute and developed the necessary new techniques and tool for our lecturers before embarking on the pilot study. There were many challenges and learning points in the process of integrating the contextualized Gold Standard project-based learning in project modules offered in SEG, NYP. This section details some of these challenges and offers recommendations to those who are interested in implementing project-based learning in polytechnic education.

Change of Teaching and Learning Practices

Successful project-based learning implementation requires the active participation of an engaged staff and his/her willingness to step out of their comfort zone to embrace the change instead of sticking to traditional classroom teaching and learning. While some levels of resistance to the implementation of the project-based learning contextualized model are inevitable, there are strategies that could overcome this change resistance. First, the team could share the benefits of implementing project-based learning to both lecturers and learners using the success stories of the pilot studies. Second, collect more input from the lecturers on how they feel about the project-based learning implementation and how they would make the approach and process better. Third, provide more support and structured training to progressively train all the lecturers in using the Gold Standard project-based learning to re-design their project modules.

Sourcing for Suitable Authentic Project

The greatest challenge is to source for an authentic project that is provided by the industry and aligned with the module learning outcome. Currently, module leaders who are in-charge of the project module are expected to source for an industry partner to collaborate on their project-based learning implementation. They are to manage the industry expectation of the project outcome to ensure that the industry partners see the value of continuing the collaborations. It is recommended to have a dedicated team of staff to actively source for companies for collaborations and connect them to respective module leaders for further discussion on project-based learning collaboration. This could free up more times for module leader to focus on their module design and delivery.

Conclusion

In summary, two project modules successfully implemented project-based learning by adopting the Gold Standard project-based learning model and using the techniques and tools to support learners. Despite the initial success, there are certainly rooms for further improvement such as reviewing the design of the project and teaching content, identifying the missing links to increase learners' confidence in completing their project, as well as getting more buy-in from lecturers on the model.

Based on the results and findings from the pilot runs, the team is currently rolling out the implementation of the Gold Standard project-based learning model to all diplomas in SEG by phases. The team will also plan to provide more structured training to support module leaders in integrating project-based learning into their project modules, as well as equipping them with the facilitation skills which are essentials in delivering project-based learning lessons.

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Appendix 1 – Evaluation Questions to the Learners

The following questions are asked according to the MUSICS model to assess the impact of project-based learning on learners' motivation in six dimensions, namely empowerment, usefulness, success, interest, caring and soft skill. The questions were randomised in the survey that was administered to learners.

<u>Empowerment</u>

1. I had the opportunity to decide for myself how to meet the project goals.
2. I had the freedom to complete the project tasks my own way.
3. I had options in how to achieve the final outcome of my project.
4. I had flexibility in what I was allowed to do in this project.
5. I had control over how I work on the project.

<u>Usefulness</u>

6. In general, the project was useful to me.
7. The project was beneficial to me.
8. The knowledge I gained in this project is important for my future.
9. I will be able to use the knowledge I gained in this project.
10. I found the project tasks to be relevant to my future.

<u>Success</u>

11. I am confident that I could get the grade I want in the project.
12. I could solve most of the challenges in this project.
13. I was capable of getting a high grade in this project.
14. Throughout the project, I felt that I could accomplish the project tasks.

<u>Interest</u>

15. The project held my attention.
16. The teaching methods used in this project held my attention.
17. I enjoyed the teaching methods used in this project.
18. The teaching methods engaged me in the project.
19. I enjoyed completing the project tasks.
20. The project was interesting to me.

<u>Caring</u>

21. My lecturer was available to answer my questions about the project.
22. My lecturer was friendly.
23. I believe that my lecturer cared about my feelings.
24. My lecturer was respectful of me.
25. My lecturer cared about how well I did in this project.
26. My lecturer was willing to assist me if I needed help in the project.

<u>Soft Skill</u>

27. The project allowed me to create new ideas as solutions to the design question.

28. I managed relationships and work collaboratively with my teammates in this project.
29. My teammates and I communicated effectively when working on the project.
30. I was able to think and rationally about what to do in the project.

Glow, grow and interventions (G2I) feedback tool for peer assessment in a nursing course

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Abstract

According to Singapore Nursing Board (SNB), the accredited nursing curriculum provides correlated theory and practice to prepare graduates with a level of competence required for safe effective nursing care at the level relevant to the programme offered (SNB, 2019). Nurses are required to demonstrate clinical reasoning, problem solving and critical thinking skills during the course of their work.
One of the gaps identified among the student nurses was the ability to receive and give constructive feedback for self and others respectively. This is a crucial skills as nurses need to be reflective practitioner to constantly improving their skills with feedforward feedback. The ability to communicate well and provide constructive feedback to patients during discharged education could enhance patients' safety and reduce the readmission for patients who needs to perform nursing care independently at home.

The paper examines how the "Glow, Grow and Intervention" (G2I) feedback tool is used in peer assessment that supports the students' ability to provide constructive feedback and using feedforward feedback to enhance their learning.

The G2I feedback tool developed by the School of Health Sciences at Ngee Ann Polytechnic has a component of glow which highlights the learner strengths and a component of grow which depicts the area that can be improved and lastly the intervention component to provide suggestions for the learners to translate feedback into action. The learner can decide to prioritise which interventions to carry out or not to carry out based on their own readiness. It is an iterative cycle of learning that promotes self-efficacy.

The G2I feedback tool is constructed based on the self-efficacy theory, whereby the learner's belief in their ability to carry out a task successfully prepared them to deepen their learning and retention toward skills competency and academic success.

Through the use of the G2I feedback tool, student nurses are empowered to develop effective communication skills and deepen their critical thinking skills that are crucial in the clinical setting to provide safe quality care to the patients in the clinical setting

In this study, two self – constructed surveys were utilised to obtain the findings on the usefulness of the G2I feedback tools used in the different modules mainly in the nursing laboratory skills (NSL) sessions which focus on hands-on practical skills and also in the tutorial sessions in the nursing sciences (NS) modules which focus on acquiring knowledge.

468 students participated in the NSL surveys (in October 2020 semester) and 547 students participated in NS survey (in April 2021 semester).
468 NSL students from October 2020 semester and 547 NS students participated in the survey to study the usefulness of G2I feedback tool. The consistent findings of the survey showed that majority of the students in both modules found the G2I feedback tool useful to help them in acquiring skills to provide constructive feedback confidently. The "feedforward feedback" process also enabled students to improve their skills and knowledge for the modules. Others findings showed that the G21 feedback tool allowed students to deepen their learning through a process that enabled them to reflect and learn collaboratively with their peers, and these are critical skill that a registered nurse needs in the course of work to deliver safe and quality nursing care. The peer assessment also allowed them to develop teamwork, enhanced communication, promote critical thinking skills, learning together.
The findings of the study could explore more on the effectiveness of peer assessment using the G2I tool that could be implemented in other modules to enable the learners to deepen their ability to reflect and acquire lifelong skills in assessing and providing feedback to others. It also equipped them with skills to self-assess and improve on their own work and also learning together with their peers.
More research will be needed to explore the impact of the G2I feedback tool has on the different cohorts.

Keywords: *feedback, peer assessment, lifelong skills*

Introduction

Nurses are primary healthcare professionals who are responsible for providing quality nursing care to patients in the healthcare setting. The ability to provide good feedback is an essential skill to empower nurses in the area for patient's education and assessment for patients' skills competency. The feedforward feedback will enable patients to carry out better care for

themselves upon discharged and reducing the opportunity for readmission due to poor discharged care at home. In addition, nurses needs to be reflective practitioner to constantly improving their skills competency with constructive feedback

Gray (2016) mentioned that while feedback focuses on current performance, feedforward looks ahead to the next assignment as it offers constructive guidance on how to improve. A combination of feedback and feed forward ensures that assessment has an effective developmental impact on learning. It also encourages lifelong learning with the intent to develop reflective mindset towards their own learning by leveraging on feedforward for future learning and improvement.

According to Wiliam (2018), peer assessment also promotes the development of higher thinking skills which are crucial skillsets needed when the students nurses are delivering nursing care in the clinical setting.

The features of the self-constructed G2I feedback tool has provided the students to give constructive feedback to their peers and to inculcate the need for self-reflective practices and the effective use of the feedforward feedback to hone their learning. Gray (2016) highlighted that feedback is not limited to the given task but also optimize the students' learning by listening to the feedback given to others.

Self-efficacy theory & Nursing Education

Bandura's social cognitive theory (1986), highlighted that in order to achieve academic confidence, the learner with high self-efficacy would feel "capable" of successfully performing school-related task. Other studies have also revealed a strong correlation between self-efficacy and academic performance (Bandura, 1997). Additional research also shows that when students believe they are capable of achieving an academic task, it will empower them to persist and overcome challenges to successfully perform in their assignment. Likewise, students who lacked confidence in their ability to perform a task or overcome a challenge, are more likely to give up and avoid the task. (Bandura, 1997).

The G2I feedback tool is developed based on the self – efficacy theory the anchors on the belief that all learner have abilities including the ability to meet the challenges ahead of them and to complete a task successfully (Akhtar, 2008).

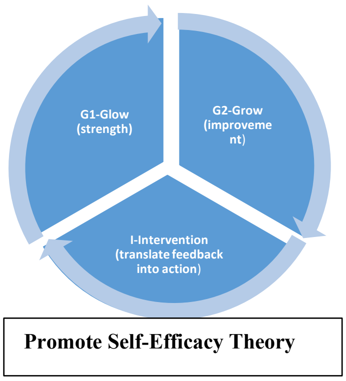


Figure 1: The 3 components of the G2I feedback tool.

In nursing, self-efficacy theory supports nurses in their clinical skills competency development as accounted in Bandura (1997), nurses with higher level of self-efficacy tend to yield better learning retention and more able to apply the learning to a new patient situations in the clinical setting due to the positive belief they have good nursing skills competency.

The G2I feedback tool was developed for student peer assessor to provide feedback to their peers during a mock group presentation in the NS modules. This tool allowed students to follow a structure as shown in Figure 1 so that feedback can be translated into action and to enable their peer learners to do better for the graded group presentation. Peers also learnt from others through the sharing of the constructive feedback. Refer to figure 2 for the G2I template that the students uses for their peer feedback.

G2I template for feedback for students (sample)

Feedback	Self-evaluation	Peer's evaluation	Lecturer's evaluation
Glow (strengths)			
Grow (areas for improvement)			
Intervention(s)			

Figure 2: The G2I template tools given to the students to share their respective findings for the mock presentation for the NS and NSL modules.

The G2I tool specifically included the area of glow to bring the learner to observe the area of strengths in themselves and also their peers. As for the area of grow, the feedback given to themselves and peers have the feedforward component that enables them to work towards better success with proposed interventions to carry out for improvement. It supported their confidence building, paving the way for greater academic success by enhancing skills competency and promoting teamwork as highlighted in the self-efficacy theory.

Item no	Modules (all tutorials)	Cohort and year of study	No of participants
1	Integrated Nursing Sciences 2.1 (INS 2.1)	2021 / Year 2	195
2	Integrated Nursing Sciences 2.2 (INS 2.2)*	2021 / Year 2	83
3	Woman and children health (WCH)*	2021 / Year 2	162
4	Integrated Nursing Sciences 3.1 (INS 3.1)	2020 / Year 3	107
Total participants from all modules are			**547**

Table 1 show the participants from the different NS modules for Year 2 (INS2.1, INS2.2, WCH) & Year 3 (INS3.1) in April 2021 semester.
*Same group of students doing the INS2.2 and WCH modules.

There were 547 students from 4 modules in Year 2 & Year 3 in NP's Diploma of Nursing who used the G2I tool for the peer assessment. Same group of the Year 2 students who took part in the Integrated Nursing Science (INS 2.2) and Woman's Children's Health (WCH) were invited to participated in the surveys, which were conducted after using G2I feedback tool in the peer assessment.

The participants for the Nursing Skills Laboratory (NSL) modules across year 1-3 are represented in the following as shown below;

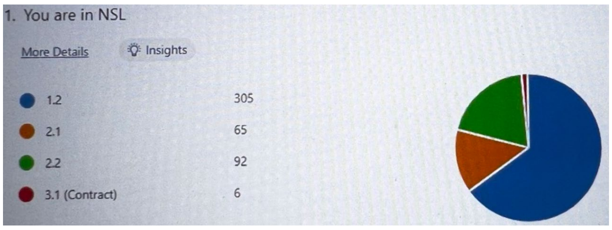


Figure 3- show the participants from the different NSL modules for Year 1 to 3 as depict in year 1 is NSL1.2, year 2 is NSL2.1 and NSL2.2. In Year 3 is NSL3.1 in October 2020 semester. The total numbers of 468.

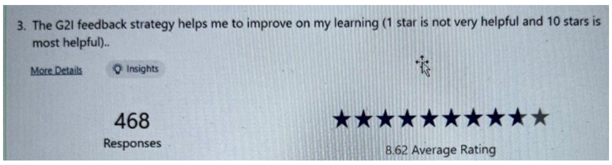


Figure 4- show the rating of the students from the NSL modules on how the G2I feedback tools have supported their learning. The results above shows rating of 8.62 out of 10 on the usefulness of the G2I feedback tool used in the peer assessment to enhance students' learning showed similar findings from the study by Liu and Carless (2006) which supported that peer feedback enhance and motivate students to learn.

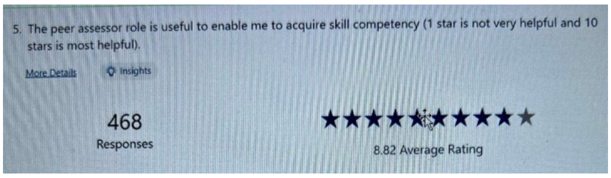
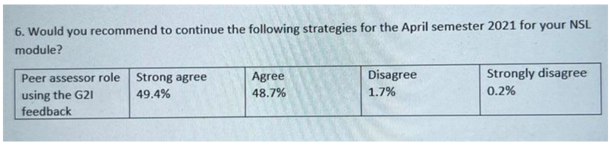


Figure 5- show the rating of the students from the NSL modules on achieving the skills competency through the peer assessor role.

The findings from the NSL module on the usefulness of G2I tool supported their role as peer assessors, showed a rating of 8.82 /10 which indicates that students find the G2I tool and its contents useful in helping them develop their skill competency (figure 5). This is also in alignment with Lu and Law (2011)'s findings where they mentioned that peer assessment enhances students' learning and enables them to be more reflective and improve on their learning outcomes, enables students to think more critically and learning effectively

Table 2 - show the percentage of students that recommended the peer assessment using the G2I feedback tool to be used for the next batch in April 2021 semester in the NSL module.



6. Would you recommend to continue the following strategies for the April semester 2021 for your NSL module?

Peer assessor role using the G2I feedback	Strong agree 49.4%	Agree 48.7%	Disagree 1.7%	Strongly disagree 0.2%

98.1% of the students recommended to continue the peer assessment using the G2I feedback tool for their juniors as they felt that using the G2I feedback provided them with the opportunity to build their nursing skills competency that developed their critical thinking skills as they have to provide actionable feedback to help their peers improve and also enhance teamwork.
However, a small percentage of students (1.9%) were hesitant to recommend to use G2I feedback as they felt there were inconsistency in the quality of peer assessment and quality feedback that can be translated into action. This may be due to the students not having adequate confidence in their ability to provide quality feedback to their peers. Some also felt that it was stressful to give peer feedback on the go especially if it was their first time giving constructive feedback to their peers. They were unsure if their peers are receptive to their feedback.

Similar findings for the NS modules are included the following below;

Table 3 - show the percentage of students that recommended the peer assessment using the G2I feedback tool to be used for the next batch in October 2021 semester in the NS modules.

Q5 Would you recommend G2I to continue for next batch of students

No	Module names Year 2 and Year 3	Cohort / Participants	Yes	No
1	(Tutorials sessions) Integrated Nursing Sciences 2.1 (INS 2.1)	2021 (195)	86.7%	13.3%
2	Integrated Nursing Sciences 2.2 (INS 2.2)	2021 (83)	88%	12%
3	Woman and children health (WCH)	2021 (162)	85.2%	14.8%
4	Integrated Nursing Sciences 3.1 (INS 3.1)	2020 (107)	89.2%	10.8%
Total participants		**547**		

The findings show similar trends in both modules that more than 80% of the students from the various cohort have recommended to continue the G2I feedback tool with the peer assessment for the next batch of students shows that the students noted the usefulness of the G2I tool for their learning.
Similar rationales for both modules are identified for recommending the modules to continue with the peer assessment role using the G2I feedback tool included the opportunity to enable them to be more confident in giving quality feedback, prepare them well for the clinical placement, to allow them to learn in a safe environment, can learn from the feedback that were given to their peers and also opportunity to improve for the graded assessment.
Even though the surveys were done in different semesters on different batches of students, the findings were consistent on the benefits of the peer assessment using G2I feedback tools. Some students mentioned that it was stressful to provide timely, specific actionable feedback to their peers and required more practices to enhance the quality of providing useful actionable feedback on the go. This can be a good feedforward feedback for the teaching team to consider for the next implementation to provide more practices for students to develop their confidence in providing quality feedback to their peers. It will also reduce the inconsistency of providing actionable feedback to peers as their self-efficacy and confidence is increased through more practices

Table 4 show the summary of the key findings based on the two modules (NSL and NS);

<table>
<tr><th>Item no</th><th>Module and Year in nursing</th><th>Glow feedback</th><th>Grow feedback</th></tr>
<tr><td>1</td><td>NSL 1.2, NSL 2.1, INS 2.2, NSL 3.1 from Year 1 to Year 3 (practical)</td><td rowspan="2">Confidence building in giving quality feedback and deepening skills competency, promotes critical thinking and reflective practices and teamwork.</td><td rowspan="2">Stressful to provide timely, specific and actionable feedback to their peers and required more practices to enhance the quality of providing useful actionable feedback to theirs peers for improvement.</td></tr>
<tr><td>2</td><td>NS INS2.1, INS2.2, INS3.1 from Year 2 and Year 3 (tutorial</td></tr>
</table>

Conclusions

Peer assessment using the G2I feedback tool is useful to be implemented with the intent to develop the students' ability to provide constructive feedback, improve communication, self-efficacy and critical thinking. It is recommended that educators could also leverage on the G2I feedback tool to provide students' feedback. The tool also helps to strenghten their perceptions of their self-efficacy leading to academic success and also deepening of skills competency through this positive self belief.

A longitudinal study will be useful as it could assess the long term impact on the use of the G2I feedback tools and its application especially during their clinical placement. Peer assessment is also a good way to develop their professional competency as a registered nurses in the workplace.Whereby they learn to leaverage on the peer feedback to enhance their skills competency.

The consistency in providing feedback using the G2I feedback tool will enable the students and their peers to develop good reflective practices to provide them with the opportunity to translate the feedback into action in both the practical hands-on sessions and tutorial classes. Consequently, this will improve their level of self-efficacy and self-confidence towards skills competency and academic success.

Acknowledgements

We would like to acknowledge Mr Andy Lee, Ms Hui Leng Tan and Ms Shirley Williams from Ngee Ann Polytechnic, Centre of Learning and Teaching Excellence (CLTE) for their support on reviewing our papers.

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Certificate of Approval

The approval certificate is given to the organising committee for the purpose of maintaining and publicizing the record of the symposium.

A SOLUTION FOR SCIENCE PHOBIA PROBLEM IN JAPAN: A TRIAL ON CULTIVATING INTERESTS IN SCIENCE EXPERIMENTS IN JUNIOR HIGH SCHOOL STUDENTS THROUGH DISTANCE EDUCATION

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Abstract

The paper provides a new way to reduce the number of the junior high school students who dislike science. Some local junior high schools don't have enough equipment for implementing scientific experiments, which consists of one of the reasons for increase of the students who dislike science. In such circumstance, National Institute of Technology, Akita college (Akita KOSEN) has started "Online Science Experiments for Local Junior High School Students" since academic year of 2021. This program is also aimed at cultivating their mindsets that they always think "why" when they learn something new in science.

The program is offered by the combination of online experiment and face-to-face one. Online experiments include a movie of the experiment and a mini-lecture from Akita KOSEN, whereas face-to-face experiment is carried out by the junior high school students, mimicking the procedure which a teacher on online conducts. Scattering of light was chosen as a theme of the program. It is thought of as the occurrence of the redirection of light when an incident light ray encounters the particle in the air. The phenomenon is familiar in our daily lives, but junior high school students have not learned it during their junior high school days. So, we can convincingly evoke the interest in science in the students' minds by showing the program.

Keywords: *science phobia problem, distance education, online science experiment, students' interest, and scattering of light*

Introduction

In the paper we provide a new way to reduce the number of the junior high school students who dislike science. Some local junior high schools don't have enough equipment for implementing scientific experiments, which consists of one of the reasons for increase of the students who dislike science.

In such circumstance, National Institute of Technology, Akita college (Akita KOSEN) has started "Online Science Experiments for Local Junior High School Students" since academic year of 2021. This program is also aimed at cultivating their mindsets that they always think "why" when they learn something new in science.

The paper is organized as follows. In section 2, we describe the contents of the program in detail. Section 3 is mainly associated with discussion on the educational effects on the online science experiments by evaluating the questionnaires implemented twice (before and after the experiment) by giving the same questions to the participants. This investigation reveals students' change of mind on understanding the mechanism of light scattering through participating in the program. Section 4 ends with the conclusion of this paper. As far as previous works on distance classes are concerned, see Hyodo (2021), Inoue (2022), Soyama (2021), and Tsukamoto (2022).

Contents of the program

This section describes the contents of the program in detail. The program was conducted at ANI junior high school in Kita-Akita city, which locates about 70 km to the north of Akita city. In this time, 21 students participated in the program, which means all of enrolled students in the junior high school. The grades and the number of participating junior high school students were as follows; six seventh-grade, ten eighth-grade, and five ninth-grade students.

The program was offered by the combination of online experiment and face-to-face one. Online experiments included a movie of the experiment (or the demonstration of experiment) and a mini-lecture from Akita KOSEN, whereas face-to-face experiment was carried out by the junior high school students, mimicking the procedure which an online teacher conducted. Furthermore, three teaching staffs from Akita KOSEN helped the junior high school students to do the experiment.

One teaching staff of Akita KOSEN and the one of Ani junior high school played the role of facilitators of the experiment, whereas two teaching staffs of Akita KOSEN supported the students' conductions of the experiment. To make the event more active and efficient, we requested the students to form a group of four or five, as we can see in Figure 1.

Figure 1: Science experiment at Ani junior high school

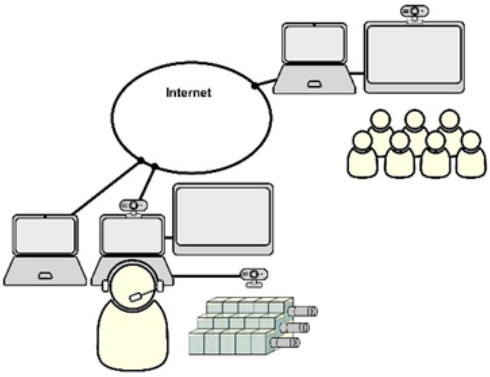

Figure. 2: The network system built for the program.

Figure 2 illustrates a network system built for being able to communicate interactively during the program. Through Microsoft Teams system, a teacher (a sender of the lecture) in Akita KOSEN was connected to the students (receivers) at experiment room of Ani junior high school. As equipment for the connecting devices, the teacher used two laptop computers; one was for the communication, the other was to confirm whether the students could watch the slides which the teacher showed without problems. The sender also utilized the document camera for giving the students detailed information on how to conduct the experiment. On the other hand, at the receiver side, a wide-angle camera was installed in order for the teacher to look out over the students.

The lecture implemented by the teacher could be seen by the junior high school students through the computer of Ani junior high school. The situation is depicted by Figure 3. Looking at the photo on the right side, we can easily see students taking a lecture from the teacher at Akita KOSEN.

Figure 3: The sender (the left photo) and receivers (the right photo)

As a theme of the experiment, scattering of light was chosen, which is thought of as the occurrence of the redirection of light when an incident light ray encounters the particle in the air. Since, although the phenomenon is familiar in our daily lives, junior high school students have not learned it during their junior high school days. So, we can convincingly evoke the interest in science in the students' minds by showing the program.

The program contained three experiments, (a) to make another colour by mixing the three primary colours of light (red, green, and blue), (b) to observe spectra of light, and (c) to reproduce a sunset and a blue sky in the laboratory by making light pass through solutions of wax. Figure 4 shows equipment used in these experiments.

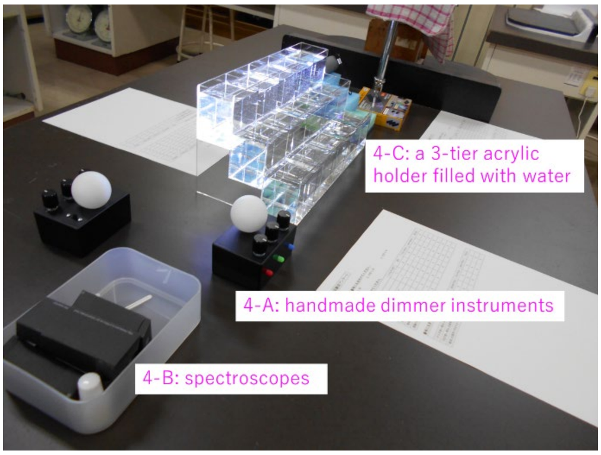

Figure 4: Equipment of the three experiments

The first experiment was to make another colour by mixing the three primary colours of light. The set most frequently used is red, green, and blue. The mixture of the three colours are required to give the sensation of white light. Figure 5 illustrates a sheet of PowerPoint, which was used in the experiment (a).

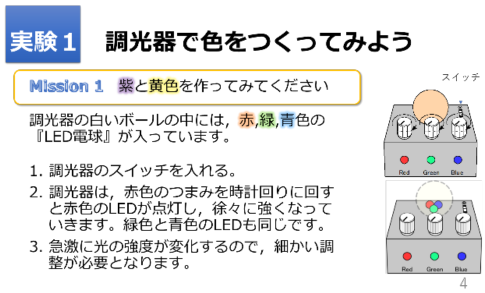

Figure 5: A sheet of PowerPoint for the experiment (a)

Using handmade dimer instruments, which were seen in Figure 4-A, students tried making several colours such as violet and yellow, which is required for the participants to think which colour(s) are needed or need not. This is shown in Figure 6.

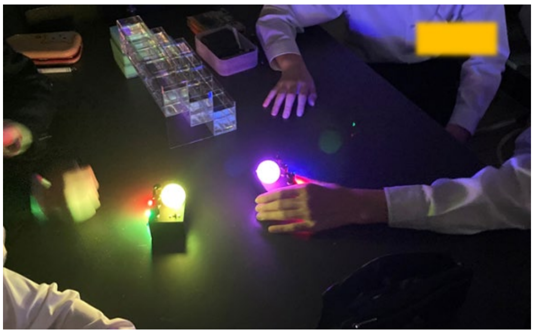

Figure 6: Mixing the colours of light gives the sensations of yellow and violet lights.

At the mini-lecture before the second experiment, the following quiz was given to the participants: *how can you separate a lot of ping-pong balls and marbles?* Students discussed a way to separate two kinds of many balls in group, and then the group's representative showed to the teacher the answer on the small whiteboard, which was given to each group in advance. The situation is indicated in Figure 7.

Figure 7: Presentation and discussion in group (the inset photo) to find the answer of the quiz *how can you separate a lot of ping-pong balls and marbles?*

After the quiz, the experiment (b), to observe spectra of light, was implemented. Figure 8 shows two examples of spectra of light observed by the spectroscope, as in 4-B shows. Photos on the left and the right sides show those from an incandescent lamp and a fluorescent light lamp, respectively. The purpose of introducing the second experiment is for students to know that spectra of light are differentiated depending on the sources of light; incandescent lamp, a fluorescent light lamp and the light from the sun.

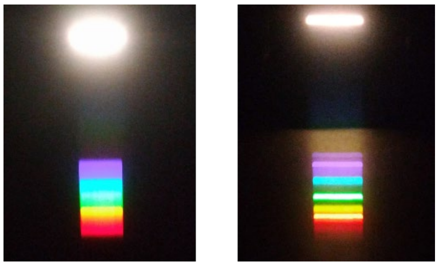

Figure 8: Continuous and discrete spectra of light.

After learning properties of light, such as a relationship between the colour and the wavelength, and the dispersion relation at the mini-lecture, students observed the spectra of light from the sun and those from a fluorescent light through a simple spectroscope, which was seen in Figure 9.

Figure 9: Students observing the spectrum of sunlight

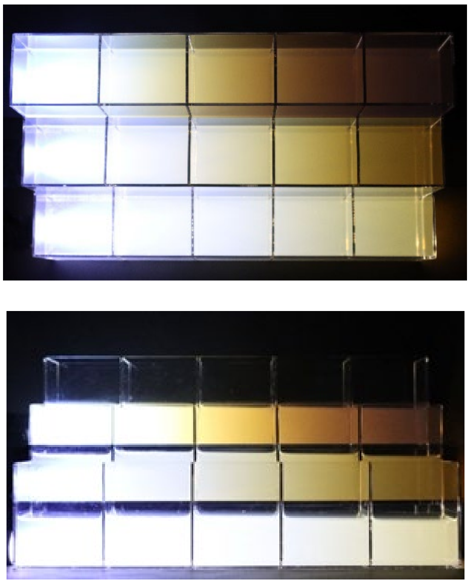

Figure 10: Variation of the colour via light transmitting through the solutions of wax.

The third experiment is concerned with (c) to reproduce a sunset and a blue sky in the laboratory by making light pass through solutions of wax. Note that the scattering of light depends on its wavelength and the concentration of particles in the air.

Figures 10 shows the variations of colour by light transmitting through the water solutions of wax. The photos from top and the bottom were those taken from above and the side, respectively. Three, six, and nine droplets of commercial wax are put into each tier of a clear acrylic holder (4-C), filled with water, in order to reproduce the atmosphere with particles on earth. A next step is to put light from a side, and one can observe variations of colour in each tier. The concentration of wax in water solution changes according to the height of the tier (bottom, middle, and top). And one can see the reproduction of the strength of blue colours on the top tier. In the top tier in Figure 10, light strongly scatters to all directions and therefore the strength on the light ray decreases more rapidly. This is why the sky is blue. On the other hand, by traveling of a light ray through a water solution, the components to the blue colour are decreasing, so that those to the red colour are survived. This means only the red light can reach to an observer's eye, which is demonstrated in Figure 11.

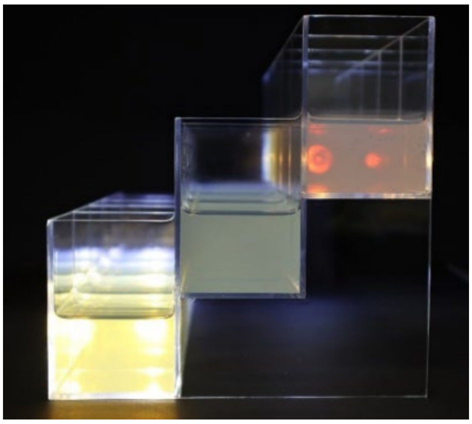

Figure 11: The light transmitting through the solution of wax.

Using the properties, one can reproduce a *sunset* and a *blue sky* in the laboratory. After explaining the procedures of the third experiment to the students by using the slide illustrated in Figure 12, the participants started the examination.

Figure 12: Sheets of PowerPoint for the experiment (c)

During conducting the experiment, we could hear some students saying ``How beautiful!" and most participants seemed to be impressed by the experiment.

We aimed at cultivating students' mindsets that they always think "why" when they learn something new in science. For the purpose, we strongly believe that students' mindsets have changed by showing the phenomena in Figure 6, 8 and 11, which lead to the cultivating the interests in science.

As an appendix, an experiment was conducted concerning scattering of light. Figure 13 shows the light of the primary colours transmitting through the solution of wax. Students seemed to easily see that the degree of transmitting length in a solution depends on the colours (or wavelength); for example, the longer wavelength a colour has, the farther it travels.

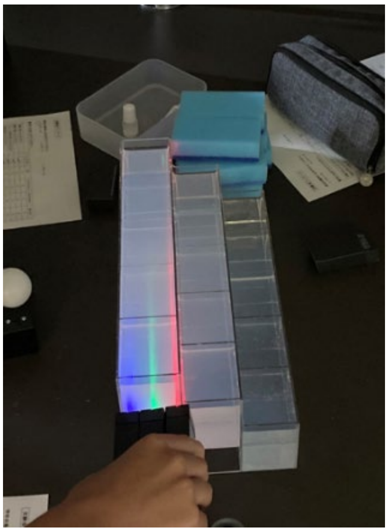

Figure 13: The light of the primary colours transmitting through the solution of wax.

Judging from the real reactions of participants, we can convincingly evoke the interest on science in the students' minds by showing the program.

Statistic Results on Questionnaires

In this section we discuss the educational effects on the online science experiments and the efficiency of understanding the mechanism of light scattering by evaluating the questionnaires implemented twice (before and after the experiment) by giving the same questions to the participants. The scale of the result for the questions is scored by five point as follows; point 1 indicates the answer "strongly positive," point 2 "relatively positive," point 3 "I cannot tell," point 4 "relatively negative," point 5 "strongly negative," respectively. Examining each mean score on the questions, the smaller the number of the mean score is, the more positive answers the result reveals. Furthermore, we offer a paired t-test for the results on the questionnaires in order to assess the educational effects on the online science experiment.

The statistic results on Q1 ~ Q8 are as follows;

Table 1: The statistic result on the question Q1 *Do you enjoy science experiments?* ($p = 0.16$)

Point	1	2	3	4	5	mean
Before	21	0	0	0	0	1.00
After	19	2	0	0	0	1.10

Table 2: The statistic results on the question Q2 *Do you enjoy observing natural phenomena?* ($p = 0.33$)

Point	1	2	3	4	5	mean.
Before	13	8	0	0	0	1.38
After	16	5	0	0	0	1.24

Table 3: The statistic results on the question Q3 *Do you like learning something in a group?* ($p = 0.10$)

Point	1	2	3	4	5	mean.
Before	16	5	0	0	0	1.24
After	20	1	0	0	0	1.05

Table 4: The statistic results on the question Q4 *Do you like making a presentation on your idea?* ($p = 0.61$)

Point	1	2	3	4	5	mean
Before	8	9	4	0	0	1.81
After	11	5	5	0	0	1.71

Table 5: The statistic results on the question Q5 *Do you like to guess what will happen and why it occurred?* ($p = 0.01$)

Point	1	2	3	4	5	mean
Before	12	8	1	0	0	1.48
After	17	4	0	0	0	1.19

Table 6: The statistic results on the question Q6 *Do you like learning science?* ($p = 0.33$)

Point	1	2	3	4	5	mean
Before	16	5	0	0	0	1.24
After	18	3	0	0	0	1.14

Table 7: The statistic results on the question Q7 *Would you like to get a job using science?* ($p = 0.49$)

Point	1	2	3	4	5	mean
Before	4	7	6	2	2	2.57
After	7	7	3	1	3	2.33

Table 8: The statistic results on the question Q8 *Do you enjoy distance classes?* ($p = 0.19$)

Point	1	2	3	4	5	mean
Before	16	2	2	1	0	1.43
After	18	1	1	1	0	1.29

The results on the questions before the experiment, especially those on Q1, Q2, and Q6, reveal that not so many students have a desire to get a job on science, although most of the students are a lot interested in experiments and observation in science. As for the result of the survey in Table 6, science phobia in Japanese students can be seen clearly by combine the result of Table 6 with the statistic result in TIMSS (2019). According to TIMSS (2019), 20.3 % of the eighth-grade students in Japan like to get a job using science, which is the least ratio in the world, compared with the fact that the international mean ratio is 56.2 %. The result may change by giving the students the program not one time but more than one time, so we will have to examine it continuously. On the other hand, the result on the question 8 (Table 8 shows) indicates that the students could take the distance class without hesitation.

Comparing the results on questionnaires *before* the experiment with those *after* the experiment, most of the results on Q1 ~ Q8 indicate dramatical improvement. The data leads to the conclusion that the program attracts the students' minds. However, through looking at the data via a paired t-test, a significant difference on statistics can be found for Table 5 (Q5), which instantiates the significant trend. The result can stem from the fact that something unexpected ensued in the experiment, which caused the clear difference on statistics. As for the value in Table 3, the tendency is attributed to the assumption that a content on experiment (b) and its group activity attract most of the participants.

Table 9: The statistic results on the question Q9 *Can you tell why the setting sun looks red?* ($p < 0.01$)

Point	1	2	3	4	5	mean
Before	0	2	3	2	13	4.30
After	9	11	1	0	0	1.62

Table 10: The statistic results on the question Q10 *Can you tell why the sky is blue?* ($p < 0.01$)

Point	1	2	3	4	5	mean
Before	2	3	2	1	12	3.90
After	7	10	3	1	0	1.90

Table 11: The statistic results on the question Q11 *Can you explain the wavelength?* ($p < 0.01$)

Point	1	2	3	4	5	mean
Before	1	0	3	0	16	4.50
After	7	11	3	0	0	1.81

Let us turn our attention to the discussion on Table 9 (Q9) through Table 11 (Q11). We need a further examination by making a comparison with other methods on education in order to induce the conclusion that the online program we propose is superior to the others, although we can see the significant differences in the results.

Table 12 shows the collected result on the question *Which item impressed you among the phenomena (12a) through (12d)*. The second and the third columns on Table 12 represent the numbers of the students choosing them and the ratio for all participants, respectively. Note that, in this questionnaire, the respondents are allowed to

select more than one answer. The most chosen answer among the four options was (12c), whose theme is little known for junior high school students. One student answered that the phenomenon of the molecules of wax floating in the water for a long time impressed him.

Table 12 The statistic result on the question *Which item impressed you among the phenomena (12a) through (12d)*

	Answer	Number	Ratio
(12a)	Mixing light of the three primary colours makes light of white colour.	4	0.190
(12b)	The light velocity in matter depends on its wavelength.	18	0.857
(12c)	The light ray can be decomposed with a spectroscope.	8	0.381
(12d)	The setting sun reproduced in the laboratory was beautiful.	3	0.143

The numerical improvements on statistics is attributed to the contents and the activities of our offering program. If providing only an opportunity gave rise to changing the students' mindset, offering these programs continuously should induce students' significant change of mind more clearly on understanding the mechanism of natural phenomena such as light scattering.

Conclusions

In this paper, we provided the example of online science experiments for local junior high school students, and also assessed its educational effects and the efficiency of understanding the mechanism of light scattering by evaluating the questionnaires implemented twice (before and after the experiment) by giving the same questions to the participants such as "In what extent are you excited at the phenomenon?", "Do you want to know much more about it?" From the results of the survey, we could see the program was beneficial for junior high school students, and attracted them.

From this perspective, the program played a role of a solution for Science Phobia Problem in junior high school students in Japan, and was served as local contribution to junior high schools.

Acknowledgements

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DEVELOPMENT OF MANUFACTURING TEACHING MATERIALS FOR BEGINNING ELECTRICAL ENGINEERING STUDENTS

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Abstract

The original sensor-car model and textbooks were developed as a teaching material to conduct manufacturing training for 1st grade students of National Institute of Technology, Fukushima College, who are beginning students of electrical engineering. The purpose of this teaching material is to get students interested in manufacturing and technology of autonomous driving systems by assembling and operating a sensor-car model from scratch. This paper introduces the characteristics of classes using this teaching material and reports on issues identified after actual training. The sensor-car model developed is approximately 15 cm in length. This sensor-car is equipped with an infrared distance-measuring sensor, a control circuit composed of a small-size breadboard and electronic components, a gearbox, and a battery. Additionally, this teaching material can be easily assembled and disassembled by students for repeated use. This sensor-car model begins to move forward when switched on and automatically stops a short distance in front of an obstacle. If the sensor-car model gets too close to the obstacle, it moves backward and keeps the set distance. This distance and running speed of the sensor-car model can be adjusted by turning the knob of the variable resistor included in the circuit. The teaching materials have been used for the class of experiment for our 1st grade students for six years and improved. The steps of the class of experiment are follows: First, the "simple preliminary experiment" using the electronic components included in the teaching materials is performed. Next, the control circuit and car body are assembled. Finally, a competition is held using the completed sensor-car models. The results of a questionnaire after the class showed that students enjoyed learning about electric circuits and experiencing manufacturing. And they also desired to create more advanced robots and autonomous driving systems. Based on the above results, we will continue to develop the practical teaching materials to meet these requests.

Keywords: *teaching materials, electrical engineering, manufacturing training, sensor-car model, autonomous driving*

Introduction

In recent years, more young Japanese are moving away from the sciences. New students entering National Institute of Technology, Fukushima College (NITFC) also tend to have little interest in science and engineering. Many students in the Department of Electrical and Electronic Systems Engineering had little interest in and had difficulty with experiments even after entering the program. Therefore, we decided to review the curriculum for the experiment. We have been teaching electrical engineering experiments to mechanical engineering students who do not specialize in electrical engineering. Using the experience gained there, we devised content that would encourage students with little interest in electrical engineering to actively engage in the experiments. In the past, traditional basic experiments were often boring and did not hold much interest for students. In addition, there was a lot of group work, which tended to leave the operation to others.

We developed a "sensor-car model" as a teaching material that each student can assemble by themselves, and work-sheets and explanatory textbooks were also created to easily summarize the results of the experiments. This paper describes the sensor-car model we developed and the procedure of the experimental class using this model. This class aims to motivate 1st grade students of NITFC to become interested in electrical engineering. In addition, the effects of this class on students will be discussed based on the results of the questionnaire. It will also discuss the contents of the practical training that should be introduced in the future.

Teaching materials

In order to interest the students, the teaching materials were related to autonomous driving systems, which has been developing recently. The teaching material we developed is the sensor-car model. The sensor-car model

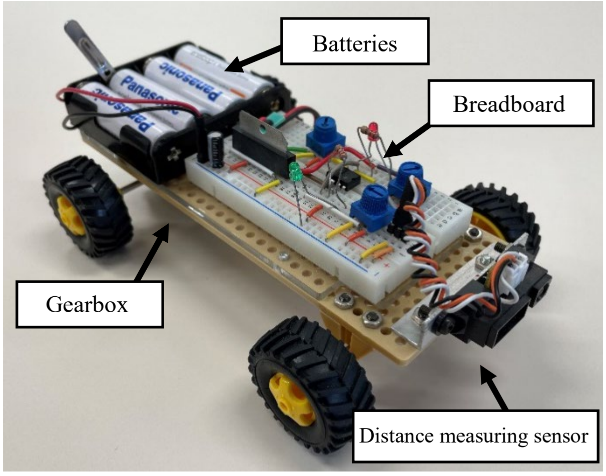

Figure 1. The sensor-car model

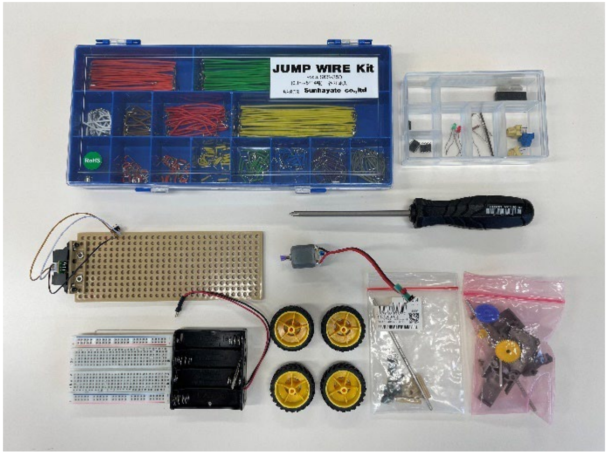

Figure 2. The complete kit of teaching materials

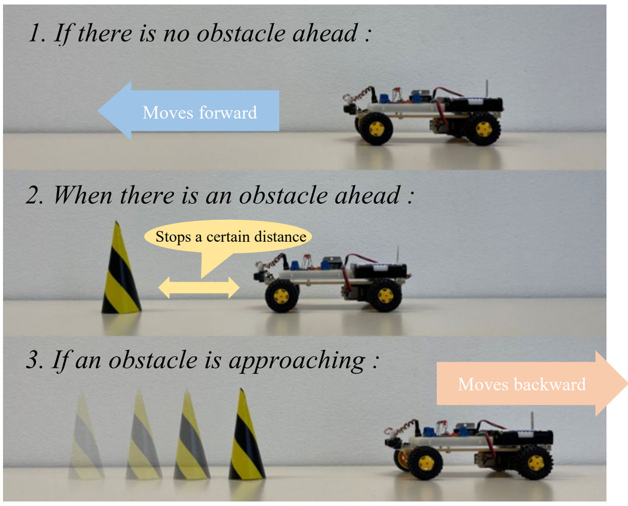

Figure 3. The operation of the sensor-car mode

is shown in Figure 1. The sensor-car model has an approximately 15-cm body and is equipped with an infrared distance-measuring sensor, a breadboard, and batteries. All body parts and electronic circuit parts can be disassembled. In the manufacturing training, all parts are assembled from disassembled. The complete kit of teaching materials is shown in Figure 2.

The operation of the sensor-car model is shown in Figure 3. If there is no obstacle ahead, the sensor-car model moves forward. When there is an obstacle ahead, the sensor-car model stops a certain distance before the obstacle. If an obstacle is approaching, the sensor-car model moves backward.

The distance at which the sensor-car model stops and the speed of the sensor-car model can be adjusted with the volume resistor.

Contents of manufacturing training

The manufacturing training consists of three 90-minute classes. Approximately 15 students take the course at a time. One set of teaching materials will be used per person.

1st week : 90min

Perform a simple preliminary experiment using components from the teaching materials. Learn about the use of breadboards and electronic components.

2nd week : 90min

Build the control circuit on a breadboard. Assemble the gearbox. Assemble the car body.

3rd (Final) week: 90min

Assemble the car body. The car body, gearbox and control circuit are combined to complete the sensor-car model. The sensor-car model is adjusted and the competition is held at the end.

Competition

In the competition, contestants compete in the art of adjusting the control circuit of the sensor-car model. Competition shall be on a one-on-one tournament basis. The first to third places in the competition results will receive points in the report submitted after the experiment. The course of the competition is shown in Figure 4. The pre-start competition is shown in Figure 5.

Competition Rules

1. Two cars start at the same time. (using electronically controlled gates).
2. The player who stops the car first within the designated area in front wins.
3. If the car crashes into an obstacle, the player is disqualified.
4. If the car stops outside the designated range, the player will also be disqualified.
5. If two cars stop at the same time, the player closer to the obstacle wins.

To win over the opponent, the speed of the sensor-car model must be increased. However, faster speeds also increase the likelihood of crashing into walls, so careful adjustments must be made. Everyone is given the same amount of time to adjust the sensor-car model.

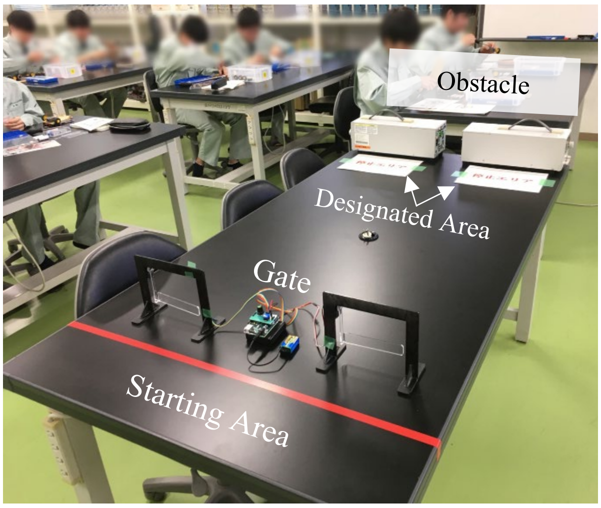

Figure 4. The course of the competition

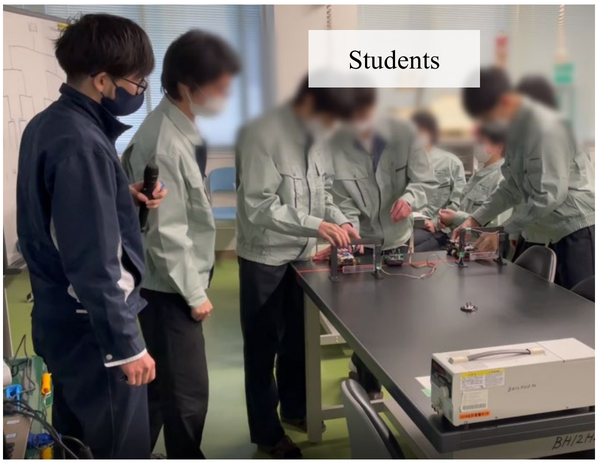

Figure 5. The pre-start competition

After the experiment is completed, students are required to submit a written report. The report is in a fill-in-the-blanks descriptive format. The number of sections to be written was kept to a minimum to avoid burdening students. The description section includes a column for the results of the preliminary experiments and a free description section. The free description section includes items to consider other circuits by applying the circuits handled in the experiment and items to describe their impressions of the experiment.

Questionnaire Results and Discussion

Conduct a questionnaire for students at the end of the academic year. The questionnaire has eight items rated on a five-point scale and two free-text items. The 5-point scale was set as [5: Excellent, 4: Very Good, 3: Good, 2: Average, 1: Poor].The results of the questionnaire conducted in FY2020 are shown below.

Question 1 asked for a questionnaire regarding the overall content of the experiment. The specifics of the questions are listed below. The results of the questionnaire for Question 1 are shown in Figure 6.

Q1-1: Was the difficulty level of the experiment appropriate?
Q1-2: Was the number of experiments conducted appropriate?
Q1-3: Was the content of the experiment appropriate?

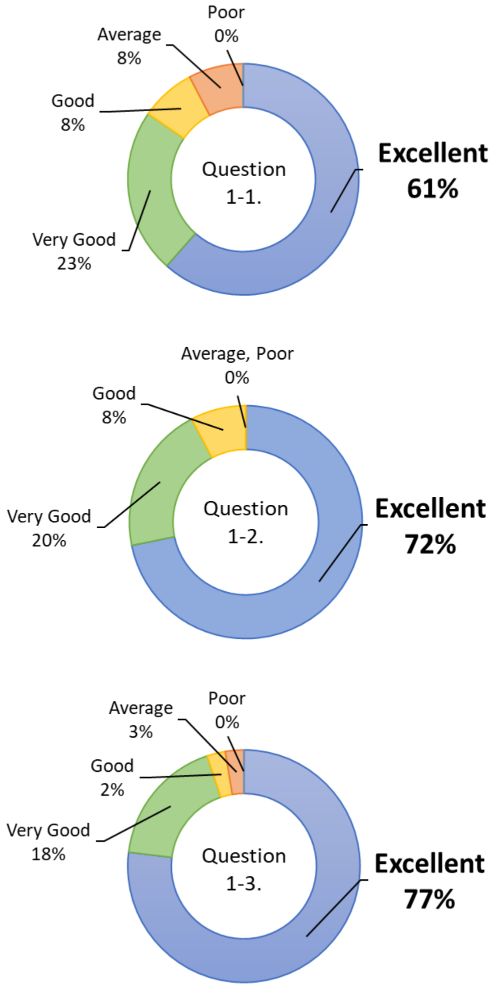

Figure 6. The results of the questionnaire for Question 1

Regarding the difficulty of the experiment, 84% of the students answered that it was Excellent and Very good. Therefore, the difficulty level was appropriate. With regard to the number of practical training sessions, 72% of the students answered Excellent, and 28% answered Very good and Good. The results showed that about 30% of the students wanted to spend a little more time on the experiment. With regard to the quality of the experimental content, 77% of the students answered that it was Excellent and 20% answered that it was Very good and Good. In other words, we found that about 20% of the students wanted a more varied hands-on experience. To summarize the results of Question 1, the majority of respondents agreed that the current content of the training is appropriate for each question.

Question 2 asked for a questionnaire regarding the teachers' explanations. The specifics of the question are presented below. The results of the questionnaire for Question 2 are shown in Figure 7.

Q2-1: Was the ease of listening to the explanation appropriate?
Q2-2: Was the clarity of the explanatory slides appropriate?
Q2-3: Did you fully understand the content of the experiment as explained by the teacher

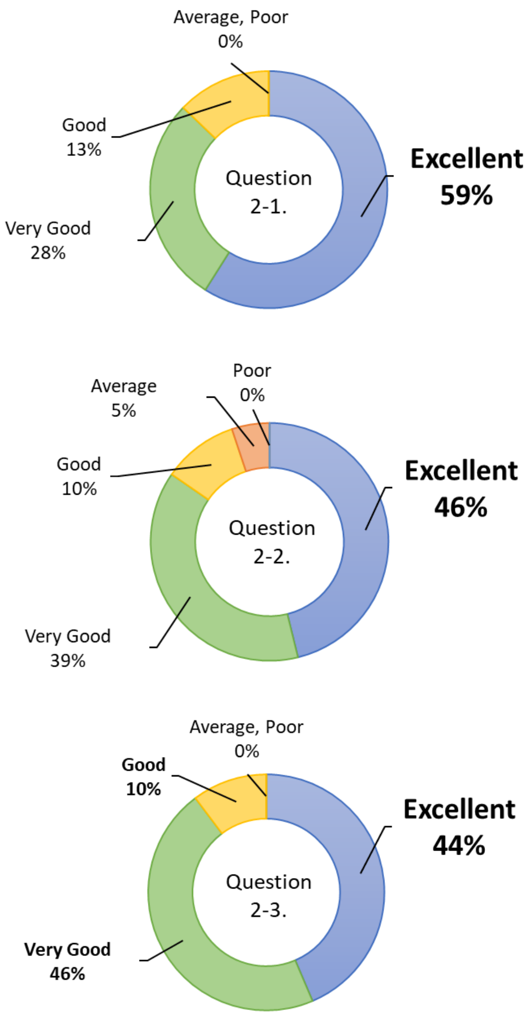

Figure 7. The results of the questionnaire for Question 2

Not a single student responded that the ease of listening to the explanation was Average and Poor. This may have been the result of the teachers' use of microphones and their efforts to speak slowly during the explanation. Regarding the ease of viewing the explanatory slides, 95% of students responded Excellent, Very good, and Good. 5 % (2 persons) of the students answered that it was Average. We found that more consideration needs to be given during the experiment to the legibility of the explanatory slides. We would like to reduce to 0% the number of students who respond that the future is Average and Poor. 100% of the students responded Excellent, Very good, and Good in terms of their understanding of the experimental content as explained by the teacher. Not a single student responded that it was Average and Poor. We conclude that this result may have been due to the fact that we were able to carefully implement the instruction by distributing printed notes with explanatory slides and supplementary materials.

Question 3 asked about the content of the competition. The specifics of the question are presented below. The results of the questionnaire for Question 3 are shown in Figure 8.

Q3-1: Did you enjoy the competition?
Q3-2: What do you think about the inclusion of competitions in the training?

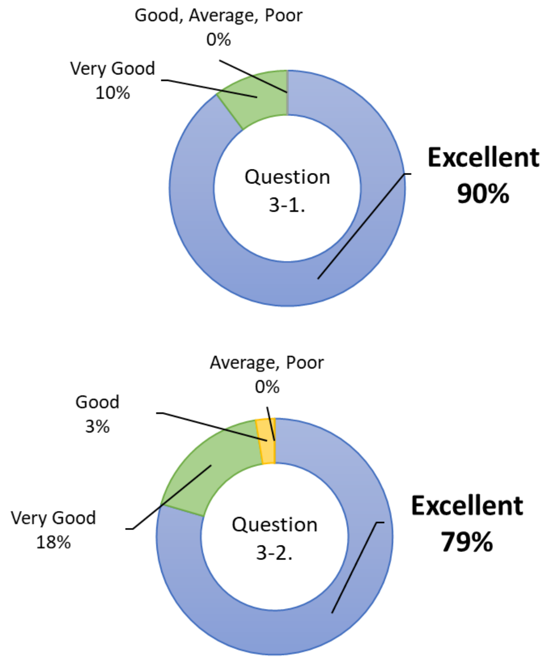

Figure 8. The results of the questionnaire for Question 3

When asked if the students themselves enjoyed the competition, 90% of the students responded that it was very good, a very favorable response. There were no negative comments from students regarding the inclusion of competitions in the practical training, and the implementation of competitions is considered to be meaningful.

Question 4 asked students to respond freely to the following questions.

Q4-1: What would you like to work on in an experiment or practical training?
Q4-2: What do you want to make or are interested in making?

The most common responses to question 4-1 were more advanced (autonomous) sensor-car model and robot production. The majority of the students seemed to have developed an interest in building devices that apply electronic circuits after having built control circuits using sensors with the students' own hands. The most common responses to question 4-2 were programming and 3DCG production. In the future, programming for control will be essential for robot fabrication. 3D CAD design is also a technique that should be mastered in designing robot chassis. We think that in the future, consideration of incorporating robot development as a theme into experiments may be necessary to meet the needs of students.

Conclusions

In this paper, we introduced the teaching materials we developed. We also experimented with the teaching materials and administered a questionnaire to the students. Consideration of the questionnaire results shows that fewer students are having difficulty with the experiments. Before and after the introduction of this practice, we felt a change in the students' attitude toward the experiment. In the past, most experiments were basic experiments to verify the principle, such as measuring the values of current and voltage in a certain circuit and examining the characteristics. It was our impression that those experiments were unlikely to interest students. In addition, from the results of the free writing, we found that there are many students who are interested in electrical engineering. We also feel that the number of students who have difficulty in writing experiment reports has decreased.

In between experiments, we asked the students if they had ever built plastic models or played with building blocks. Then, about 20% of all students say that they have never made plastic models or played with building blocks before. It seems that recent students lack experience in creating three-dimensional objects from two-dimensional explanatory drawings. There are a certain number of students who are not good at manufacturing and detailed work. Even these students are seriously engaged in manufacturing during this exercise. When the product is completed and works, they are thrilled to see it. Conducting competitions has proven to be very effective in bringing out the positive attitude of the students. It can be seen that even students who had little interest in electrical engineering are finding it fun to create things, feel a sense of accomplishment when they complete a task, and are discovering the joy of learning specialized knowledge in electrical engineering.

We will continue this practice in the future. We will incorporate student requests and seasonal topics in our activities to further interest students in electrical engineering.

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CULTURE TRAINING IN ENGLISH CLASSES CONDUCTING QUALITATIVE RESEARCH FOR STUDENTS MAJORING IN ENGINEERING

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Abstract

At present, there has been a relative lack of research concerning Culture Training being implemented in the English classroom. While there is ever-increasing importance for English to be used as a means of global communication, students majoring in engineering at the National Institute of Technology (NIT) have shown difficulty in developing their overall English competency. This issue introduces the added importance of students' ability to develop their tolerance of diversity and uncertainty. This study aims to fulfill two purposes. The first is to help confirm whether a form of Culture Training known as Cultural Assimilators (hereafter referred to as CA), can be introduced into NIT. The second purpose is to confirm how CA may develop students' competence in English and cross-cultural communication, and by extension contribute to English language development.

To test the effectiveness of CA, a qualitative study was conducted over two academic years using two different groups of students. Each academic year, students were divided into an experimental group and a control group. A pre-test was given to confirm no significant differences in group levels. Data were collected both in and out of the classroom. The control group received standard lessons involving passive learning, while the experimental group dedicated one-third of the class time to using CA materials with a more active learning approach. The portions of the class dedicated to CA materials were observed and recorded. At the end of each academic year, a questionnaire survey was given, and semi-structured interviews were conducted by the researcher. A posteriori data was collected after a post-test one year later.

The results from the gathered data showed that CA was effective in, not only effectively raising students' competence in English and cross-cultural communication, but also showed that students generally reacted positively to the CA materials introduced in the classroom. These results help to confirm that CA can be successfully implemented in the English classrooms of NIT.

Keywords: *English Education +α, students majoring in engineering, culture training, qualitative method*

1. Introduction

It is no exaggeration to say that a wave of internationalization and diversification has been sweeping through the English departments of colleges of technology in recent years. The primary goal of English education is to cultivate English proficiency, but the Model Core Curriculum (National Institute of National Colleges of Technology, 2017) and Courses of Study (Ministry of Education, Culture, Sports, Science and Technology, 2018) also call for cultivating intercultural communication skills and the ability to respond to internationalization in addition to English proficiency. The author has also found that English classes at technical colleges of technology should be taught in a manner that is appropriate for internationalization and cross-cultural communication. The author has been interested in whether cross-cultural training can be incorporated into English classes at colleges of technology to cultivate practical cross-cultural communication skills as well as English language proficiency, and has conducted several empirical studies.

2. The Purpose

The purpose of this study is to examine how the introduction and practice of cross-cultural training, called Culture Assimilator (CA), can contribute to English language education. Specifically, we will conduct a qualitative survey to determine whether changes and improvements in cross-cultural competence, cross-cultural tolerance, and English language proficiency can be observed.

3. What is a Cultural Assimilator (CA) in Cross-Cultural Training?

CA, which originated in the U.S. military in the 1970s, is a method of cross-cultural simulation and cultural assimilation. According to Yashiro (2005), Mizuta (1990), and Hori (1996), CA consists of stories

based on misunderstandings and mistakes caused by cultural differences. The process of how this misunderstanding occurred is then discussed by the learners. This is a type of training that promotes attributional transformation of causes by presenting participants with the basic ideas, attitudes, and role expectations inherent in other cultures, making them aware of perspectives defined by culture, and allowing them to reason from another's perspective (Mizuta, 1990; Hori, 1996). CA is also divided into those dealing with culture-specific and culture in general, and although there are few teaching materials specific to CA, those composed entirely in English have been published in Japan.

4. Literature Review

CA was originally developed as a training method to avoid local cultural friction when the U.S. deployed troops to various parts of the world (Fiedler, Mitchell, & Triandis, 1971). Therefore, the previous studies were mainly conducted in the U.S. and Europe, however, not many earlier studies exist. CA was first introduced to the world by Fiedler, Mitchell, & Triandis (1971). Subsequent empirical studies by Randolph, Landis & Tzeng (1977), Landis, Day, McGrew, Thomas & Miller (1978), and others have demonstrated similar certain effects of CA. Empirical studies dealing with specific foreign cultures include Worchei & Michell (1972) and Michel, et al (1972). Weldon, et al (1975), and Randolph, et al (1977), who conducted CA to increase white people's understanding of black people, and Albert's (1983) study, which clearly showed empirical effects, showed that CA had the effect of reducing ethnocentrism (self-cultural and ethnocentric). He noted that CA has the effect of moderating and decreasing the tendency toward ethnocentrism. There are also studies by Triandis (1984), Bandpay (2013), and others that report on different types of CA.

Fewer studies have been conducted in Japan due to the short history of CA. Sano (1998) and Triandis (1997) have used CA with foreign students in Japan, and Mizuta (1990), Iwata (1992), Ichikawa (2012, 2018), and others have used CA in English education at universities and found it to be effective from an empirical perspective. Other examples of practical application within English classes in secondary education include Ihara and Nozawa (1995a, 1995b) and Asami (2007). Few empirical studies in Japan examine the effectiveness of CA within language education, such as a report that conducted empirical research using CA with a small number of Japanese high school students for a short period (Ishii, 2010). In addition, as far as the author has investigated, this is the first qualitative study in CA.

5. The Flow of This Study

The quantitative analysis of the results of this study, which was published in Ichikawa (2021), showed significant differences in the improvement of English proficiency and the reduction of ethnocentrism when the study was conducted throughout the year, but not during the half-year period. However, no statistically significant differences were found for the test of international understanding. In this paper, we will explore the effects of the quantitative analysis through a qualitative study.

6. Subjects and Methods

The study will be conducted in an English class (English IIA, 3 credits, mainly reading) for second-year students of the technical college where the study was conducted, using the Action Research Type of qualitative research. Approximately 170 students were surveyed throughout one and a half years in the 2017 (full year) and 2018 (half-year) academic years. Specifically, the students were divided into two groups: one using CA materials (experimental group) and the other not using them (control group). In the experimental group, active learning methods were used as much as possible, and the study was divided into "in-class" and "out-of-class" sessions, using three methods: observation, questionnaire survey, and interview survey. In addition to that, a part of a follow-up survey was conducted after a post-test one year later.

Through these qualitative surveys, we hope to clarify the results by identifying and uncovering the perspectives and values of the subjects (cooperating students) as much as possible. Below is some basic information about the participants (Tables 1 and 2).

Table 1: Basic Information on Qualitative Research

Type of survey	Timing of implementation	Remarks
In-class observation	Only during the experimental group's CA implementation	Final 30 minutes of a 90-minute class (group work and discussion)
Descriptive questionnaire	At the end of the school year or the end of the first semester	Administered to experimental group with their approval
Semi-structured interview	Conducted at the end of the school year or the end of the first semester	Experimental group selected at random, and conducted with students' consent, lasted around 10-15 minutes per person.

Table 2: Participants in the qualitative survey

	2017 FY	2018 FY	Remarks
Number of participants in the survey and interviews	16	7	23 second-year students, belonging to a technical college, average age of 16.8 years old.
Number of those in the top half of English proficiency (scores)	9	4	English proficiency test used questions from EIKEN Level 3; average score was about 70 in all cases

6.1. Teaching Materials Used in This Study

"Culture Riddles" published by Nan-undo Publishing was used; each chapter consists of six pages and is written entirely in English (Table 3).

Table 3: Basic structure of the teaching material

Page 1	Illustrations and introduction.
Page 2	"The Story"; based on a true story of trouble in a different culture, 250-300 words in English, TOEIC score around 400-450.
Page 3	"Comprehension Check"; 5 questions to check comprehension of the story.
Page 4	"The Riddle"; 4 short pieces of interpretation about the trouble. Each student chooses the best and worst, and the group discusses why they chose the best and worst.
Page 5	"More Information": The students are asked to choose again one of the four options that they think best fits their interpretation of The Riddle with additional information. The instructor will later provide additional information and explanations to the students.
Page 6	"Expansion": Students discuss in groups what they would do if they were the main character or the other character, and how they would solve the problem. Afterward, students will write an English composition about what they discussed.

Here is an example of a theme.
"The boyfriend's visit".
(Shaules & Katsura. 2005. Culture Riddles-International. Unit-3, pp.25-30)

Description:
Rie, a Japanese woman studying abroad in London, lives with a Chilean woman and a Korean woman in a shared room. Rie's boyfriend comes to visit her in London, which causes a stir between the three of them. Rie tells them that he may visit and stay in the room, but they each react negatively. Rie, who had expected them to welcome him, is shocked.

7. Limitations and Restrictions of the Study

Limitations and restrictions were encountered in this study. First, the above were surveyed only for the experimental group, and the classroom observations, questionnaires, and interviews were conducted only after the CA training. This decision was made in consideration of the burden of conducting the three types of tests of the quantitative survey twice, which should have been conducted on the control group but was conducted at the same time. There were also other reasons, such as the fact that the research subjects were minors, and as such, there were restrictions from the research ethics committee of the college where the survey was conducted. It should also be noted that the survey was conducted at only one college where the authors work. It should be noted that due to the above limitations, the results of this study are not completely generalizable.

8. Results and Discussion

8.1 Results of In-class Observation

The authors observed the students as the teacher of the class during their group work and discussions, taking notes and recording them. The students were classified into three categories: "active activity group," "intermediate group," and "passive activity group. A summary of the results follows (Table 4).

Table 4: Results of in-class observation

(1) Active group (approximately 50%)
・The active activity group (approximately 50%) was positive because the text was culturally-centered and thought-provoking, and because of the group work and discussion-oriented development of the text. ・Students took the course seriously because some of the content shook their values. Some students seemed to have a spark of an idea. ・When they could not reach the model answers, they read the texts and discussed them repeatedly.
(2) Intermediate group (approximately 30%)
・The students in the middle group (about 30%) were relatively quiet and did the minimum amount of work (although they did speak up and express themselves in some cases). ・There are some cases in which students speak up and express themselves unexpectedly.
(3) Negative activity group (approximately 20%)
・They do not speak up much and do not gesture with their hands. ・This may be due to insufficient preparation or lack of English proficiency.

8.2. Discussion of In-Class Observations

The students' active participation in the class was remarkable, and it can be said that they were struggling with their values. The students' individual opinions were shared with their peers through group work, which gave them time to compare their values with those of others and lead to new insights. The situation in which students are forced to think seriously about a problem that is difficult to answer immediately encourages them to ponder, and it is easy for them to reach a state of new awareness. This was one of the goals of the program, and it seems to have been achieved since more than 50% of the students were actively engaged in the program. In addition, since the problem-solving options in the text were elaborate and the correct answer was not easy to choose, many students were unable to narrow down their choices and came up with two or more possible answers. In fact, as cultures and people's ways of thinking change, there are places where it seems that there is more than one applicable answer when applied to the current situation. This point may require careful explanation on the part of the instructors and future revisions of the textbook. Based on these observations, we feel that the CA materials we used were effective in encouraging students to think flexibly, considering the values of others and the causes of problems. In addition, indeed, some students did not understand English vocabulary during the English reading comprehension, and it was observed that they had to spend a lot of time asking and looking up English words.

8.3. Questionnaire and Interview Results

The questionnaire asked the following three questions on a single sheet of paper:

1. What do you think you would have done about the real-life cross-cultural problems you learned about in the textbook, and how you could have avoided them?
2. Did your thoughts and feelings about other cultures and foreigners change before and after the class?
3. Do you feel that your English ability has changed?
4. Please write any other comments you feel or would like to make (free text box).

The interviews focused on such topics as impressions of the CA materials and classes, and whether they felt confident in their ability to deal with cross-cultural problems and changes in their ability. We also employed a form of reviewing the contents of the collected questionnaires.

Since these two types of data collection are diverse, informative, and complex, we would like to present the results in two forms: "How to cope with cross-cultural problems" and "Impressions of the CA class". Therefore, few of the students' statements themselves appear. Through these cross-cultural troubleshooting methods and impressions of CA implementation, we would like to dig out elements that could not be read in the quantitative analysis.

As a supplementary explanation, the category "Coping Techniques" indicates the individual ways of coping with and resolving cross-cultural problems. Flexible attribution of causes" means "to consider not only one's common sense but also the influence of other cultures' values, etc., and to think about causes flexibly" (Nakano, Tanaka, 2015: 89). In cross-cultural acceptance and response, it is important to arrive at the idea of pursuing causes from awareness, and how getting people to think about this point is the key to success in cross-cultural tolerance training and cross-cultural training, and is the goal.

8.4. Discussion of Questionnaires and Interviews

FY 2017 (conducted throughout the year); Five categories were classified under "How to deal with cross-cultural problems." Techniques and other "techniques" accounted for over 70% of the total, with "flexibility in attributing causes" coming in second at about 11%. This is more important than techniques in terms of cross-cultural training, and it is important to encourage participants to think as flexibly as possible without sticking only to their ideas. This was followed by "Language (English)" and "Discrimination. What exactly does discrimination mean here? There are two types of discrimination: either you discriminate against or you are discriminated against, but in either case, it can be a source of trouble in cross-cultural and interpersonal relationships. Although we were not able to ask the students who answered "discrimination" what they meant by the word, we assume that they probably thought that they were the ones who were discriminated against in cross-cultural situations and that this caused miscommunication.

Regarding their "impressions" of the teaching materials and classes, 11 items were specified and answered, and most of them were positive. The most common response was that the course materials were good for learning both English and different cultures at the same time. In addition, some questioned the choice of options for the questions in the materials, i.e., choosing only one answer out of four. This is a question about whether the best answer regarding cause and remedy can be narrowed down, or whether there are more than two possible answers. The techniques learned and the flexibility of cause attribution followed; since the survey was conducted for approximately 10 months throughout the year in FY 2017, the overwhelming majority of comments were positive, and the feeling on the part of those conducting the survey was that the survey was sufficiently informative.

FY 2018 (Implemented only for half a year);
Five items were selected for "How to deal with cross-cultural problems," with just over 70% selecting "techniques" being the highest, followed by "flexibility in attributing causes" at just over 10%, and "language skills."

Ten items were selected for "Comments" on teaching materials and classes, followed by "Techniques," "Teaching materials," and "Classes. The flexibility of cause attribution was slightly less frequently mentioned at 7.6%, down from 12.0% in FY 2017. Overall, the number of positive opinions about classes using CA materials in FY 2018 also seems to be slightly less than in FY 2017, which is a full year, although there are many positive opinions.
This may be because the number of cooperating students is small, and since the duration of the CA classes is twice as long, the difference may be reflected in the difference in the amount learned.

8.5 The Follow-Up Survey

As the practical part of the study, a follow-up study has been conducted to check the spillover effects of the CA program. The follow-up was conducted through interviews with four students who participated in the short-term overseas training program to see if and how the results of the cross-cultural training (cross-cultural tolerance, communication skills, etc.) and motivation to learn English changed afterward among those who took the CA class and those who did not. As a result, it was found that the short-term overseas training program may have had some impact on the effectiveness of the CA courses that the students had previously taken. In addition, when asked whether their ability to cope with different cultures had improved (e.g. increased interest and tolerance) after short-term overseas training, the results seemed to suggest that they improved in terms of flexibility in attributing causes, self-identification, and introspective thinking. Finally, we considered motivation for learning a language (English), a common means of communication today, and concluded that it would have improved within the scope of the study.

9. Summary of Discussion

This section summarizes the overall considerations. Many students reaffirmed the importance of mutual understanding and the need to understand each other. They were positive about different cultures and the problems associated with them, and they were willing to resolve them as peacefully as possible, which requires both technique and language (in this case, English). In addition to their English language skills, the students also showed understanding of other cultures, and consideration for the feelings and values of others, which they tried to put into action. Although the content of the CA materials covered in the class included both culture-specific and culture-general content, the author concluded that the students were able to develop not only specific cultural knowledge but also some tips and skills to deal with different cultures in a variety of situations in today's diverse society. In addition, several respondents commented that there may be more than one answer to the question about the CA materials themselves. This recommendation is significant because some of the issues can be resolved in terms of culture, while others can be resolved in terms of individual differences and human compassion, consideration, and common sense. Since language, culture, and values are constantly changing, it will be necessary to update the teaching materials themselves.

There may be latent biases in this survey. Since the person administering the survey and the person teaching the class are the same person, it is possible that the students who responded to the survey may have written or spoken more positively or favorably than they thought. However, even after subtracting the bias, the results of this survey suggest that many of the opinions were positive.

10. Conclusions

In this study, we used English teaching materials based on real-life cross-cultural issues and observed through a qualitative survey the effects of developing countercultural tolerance and cross-cultural resolution skills and improving English language proficiency. The results were found to be generally favorable, as most of the group conceptualizations accounted for positive images and several favorable opinions received (however, this was more the case for the group in 2017, when CA was conducted throughout the year). Some students seemed to have shown a change in their attitudes toward other cultures compared to before, and the conceptual diagram also included opinions that would have recognized the importance of language skills. The students who had not yet mastered English in the CA course were also present, but their English proficiency was not as high as it should have been. In their case, there was a possibility that they would have difficulty with the class progression using the teaching materials. For this reason, it may be necessary to have the students prepare thoroughly for the class so that they can understand the story of the English text in more detail.

The author was only able to demonstrate the effectiveness of some of the quantitative research in the previous study, but the qualitative research, as described above, was generally successful. Although this is the first attempt to conduct a qualitative research study using CA at a higher education institution, as far as previous studies are concerned, at least positive aspects (cross-cultural tolerance and English language proficiency development) can be recognized. In the future, new results and effects may emerge when research is conducted under conditions that take into account the aforementioned limitations and restrictions of the aforementioned studies. Further development of the research will be expected in the future.

Acknowledgments

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AN AGILE AND ADAPTIVE COMPETENCY-BASED LEARNING MODEL FOR TECHNICAL EDUCATION

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Abstract

Education institution offering technical education must be agile to respond quickly to industry transformation and be able to work adaptively in a time when technical competencies are changing rapidly. The current approach used by most institutions for programme design is the traditional discipline-centric or module-centric model where learning outcomes are unpacked into separate modules along subject lines. This compartmentalises learning and may lead to less than meaningful learning as some learners would not be able to see the connections between modules and their applications. Whenever there is substantial change to competency requirements, it is difficult and slow for institutions to respond because competencies development is spread over many separate and distinct modules and whole curriculum needs to be completely reviewed and revised which takes some time.

In this paper, the authors will share their experiences in the design, development and implementation of a more agile and adaptive curriculum model that is able to develop learner competencies and skillsets for work and life more effectively, to respond quickly to industry dynamic needs, and to operate programmes in a highly adaptive manner. The authors will further share how they leveraged this competency-based learning model that mirrors workplace practices to facilitate co-creation of value with industry to co-develop, co-teach and co-certify competency units where learners can immediately see relevance of what they are learning. This competency-based learning model also maximises the potential of learners through flexibility in their learning pathways and intrinsically supports the lifelong-learning continuum.

Keywords: *Competency-based Learning Model, Agile Curriculum Model, Adaptable Pedagogical Learning Model, Lifelong Learning Continuum, Co-creation with industry*

Introduction

Institutions that offer technical education must be able to respond quickly to industry changes and be able to work flexibly and adaptively. The current subject-based model is experiencing tremendous challenges where curriculum changes need to be done more frequently and agility and adaptability were paramount. A fundamental shift in the way technical education programme is delivered is thus required.

The current approach used by most education institutions for programme design is the traditional discipline-centric or subject-based model. As illustrated in Figure 1, learning outcomes are unpacked into separate and distinct modules along subject lines in the traditional model. This compartmentalises learning and may lead to less than meaningful learning as some learners would not be able to see the connections between modules and their application. Usually, learners are given a project to help them to integrate and apply what they learned separately in the various modules. This may be less than effective as some learners may not be able to synthesize the learning from the different modules to carry out a task. Finally, the learners are put through separate module assessments, and the lecturer must synthesize all the different assessments into a proxy to validate the attainment of the course's learning outcomes.

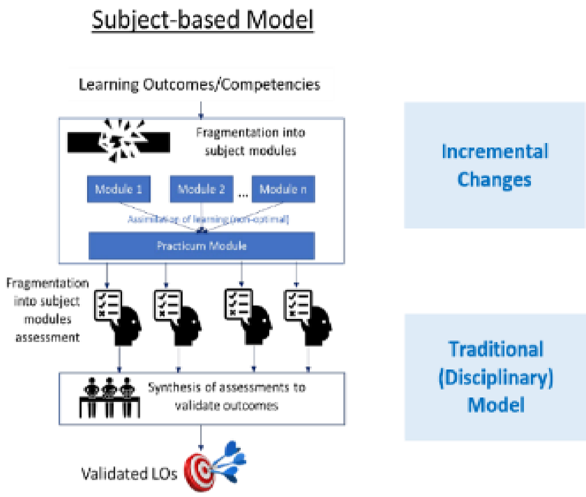

Figure 1: Traditional subject-based learning model

The module-based model has served education well, but it was created and suited for a time when things were not changing as rapidly as they do now. A key challenge with the module-based model is how when industry transforms and competency requirements change, it is difficult and slow for the institution to respond because competencies development is spread over many separate and distinct modules. Every time competency requirements change; the whole curriculum needs to be completely reviewed and revised. This takes a long time and is not in the best interest of the learners.

To better prepare learners for the *SkillsFuture* era and to be able to respond quickly to industry changes, a more agile and adaptive curriculum model is needed. The polytechnic where the authors are faculty members has embarked on a fundamental review and introduced a competency-based learning model that effectively addresses these needs. Named NYP-PCM (Nanyang Polytechnic Professional Competency Model), the authors and fellow faculty members piloted this competency-based learning model in Diploma in Business Intelligence & Analytics (DBA) in academic year 2021. Leveraging on this learning model, the authors aim to develop learner competencies for work and life more effectively, provide an agile curriculum model that can respond quickly to industry dynamic needs and be able to operate and conduct programmes in a highly flexible and adaptive manner.

Competency-based Learning Model – A System Perspective

In NYP-PCM, curriculum is made up of Competency Units (CmUs). A CmU is a contextualised learning unit that enables learners to develop the required competencies to perform specific tasks. These CmUs are grouped together into Competency Canvases (CCVs) to ensure learners can perform major tasks similar to what is expected of professionals in the workplace. As depicted in Figure 2, in this competency-based learning model, learners develop competencies and achieve the learning outcomes directly through competency units or CmUs. Each CmU enables a learner to accomplish specific tasks. In the Professional Competency Model, assessment is made directly on a learner's competencies, making the process efficient and effective. When industry transforms and competency requirements change, NYP can easily and quickly remove an obsolete CmU and introduce a new CmU to address the latest industry requirements. In a nutshell, this competency-based learning model enables an institution to respond quickly to industry changes and ensures that learners develop competencies that are current and valued by the industries.

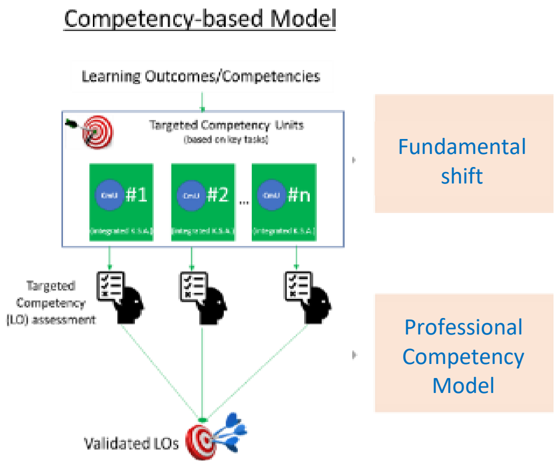

Figure 2: Professional/Competency-based learning model

The CmU is the fundamental unit for learning in the Professional Competency Model and enables learners to develop competencies to perform specific tasks that are needed by industry. A CmU is intrinsically interdisciplinary in nature and provide for real-world learning and application needs. As illustrated in Figure 3, a CmU's interdisciplinary curriculum takes reference from the *Skills Framework* and other channels that drive curriculum needs. Competency is about being able to use the right mix of Knowledge, Skills and Attitude or KSAs that will meet or exceed the demands of the task. In each CmU, learners develop the needed competency through an interdisciplinary approach that mirrors workplace practices. As learners have the benefit of learning in a real-world context where all the KSA associated with a task are acquired in an integrated manner, this learning model leads to more meaningful and effective learning.

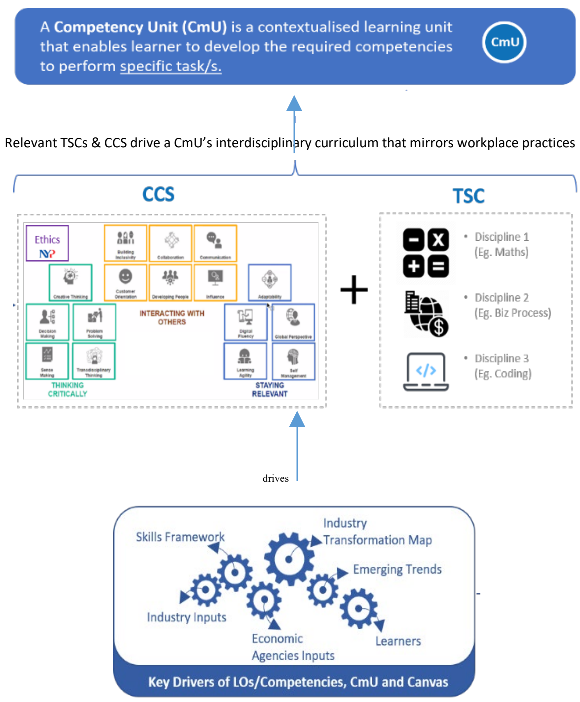

Figure 3: The Competency Unit (CmU)

The CmUs are designed to be stackable learning units pegged at varying levels, to scaffold learners' competencies development towards skills mastery. Competency Levels 1 to 5 are intended for Pre-Employment Training while Competency Levels 6 and above are designed for Continuing Education Training. As such, this competency-based learning model intrinsically supports a learner throughout the lifelong-learning continuum.

While CmUs enables learners to develop competencies to perform specific tasks, the Competency Canvas (CCV) as illustrated in Figure 4 enables the learner to synthesise competencies, acquired through related and suitable CmUs, combined with a contextualised WIU or Work-Integration-Unit, to develop and demonstrate the abilities to perform the significant tasks that is expected and demanded by the industry.

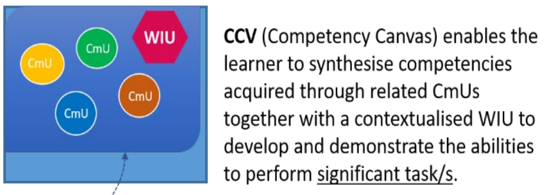

Figure 4: The Competency Canvas (CCV) & Work-Integration-Unit (WIU)

Each programme in the competency-based learning model has a Competency Map. The Competency Map enables the learning outcomes or competencies to be developed. Figure 5 is a simplified illustration of the Competency Map for the piloted Diploma in Business Intelligence & Analytics (DBA). It illustrates one pathway for a learner to develop the competency in "Analytics & Computational Modelling", one of 9 major competencies (represented by the 9 arrows) upon graduation. In this example, learners need to complete 6 scaffolded CmUs beginning with the CmU on "Statistical Research Methods" to develop the competency on "Analytics & Computational Modelling". Graduates of the diploma can continue with their lifelong learning pursuit through a Specialist diploma or other Contining Education and Training (CET) courses at higher competency levels.

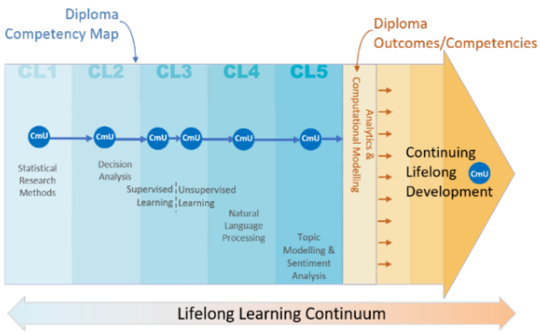

Figure 5: Simplified Competency Map for DBA

The CmUs are designed to be interdisciplinary. For example, the CmU on "Statistical Research Methods" which is pegged at Level 1 will see learners acquiring both Technical Skills & Competencies (data organisation, probability concepts, descriptive & inferential statistics, research paper writing skills) and Critical Core Skills (computational thinking, problem-solving, communication Skills) to accomplish analytical tasks and communicate analytical findings to stakeholders.

Figure 6 illustrates how the Professional Competency Model supports lifelong learning through the powerful 'Multiple entry and Multiple exit' feature. It allows learners, especially adult learners, to personalise their learning progression to meet their learning needs or objectives. The learning model intrinsically supports Recognition of Prior Learning (RPL) and a learner can thus gain access to the CmU on "Decision Analysis" and decide to pause his/her learning journey by obtaining a certification of competency in the CmU for "Natural Language Processing" in this example. This feature allows course capacity utilisation to be maximised and provides for a rich learning environment where (Pre Employmemt Training (PET) and CET learners can learn together. This Multiple Entry/Exit feature brings into focus another key element of the learning model, whcih is the built-in micro-credentialing system. There will be Competency Units and Competency Canvasses that are of immediate and direct value to industry that serve CET needs, besides that of PET. The micro-credentialing system refers to the certifiable Competency Unit and certifiable Competency Canvas that recognise the competency attainment of learners. The certification via CmU or CCV provides the critical means and recognition needed for a learner for their employability and support the learners' lifelong learning. Another powerful feature of the Professional Competency Model to highlight is that of CmU reuse. For example, the CmU on "Statistical Research Methods". Competency in statistical research methods is needed in many fields, and the CmU can be used for various programmes. This therefore enhances institutional productivity through a develop-once-and-use-many-times scheme.

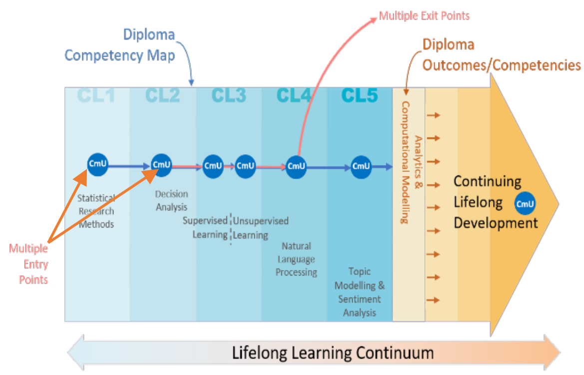

Figure 6: Multiple Entry/Exit to support Lifelong Learning

Pilot Implementation of NYP-PCM in DBA

With the adoption of NYP-PCM in DBA in Academic year 2021, there is no change in DBA's course aim, learning outcomes/competencies and curriculum as this competency-based learning model is in essense a transformative T&L pedagogical model. The Course Learning Outcomes of the diploma coutse will be achieved through Competency Units (CmUs) instead of the traditional subject-based modules. There are 9 course competencies (figure 7) upon graduation that learners will be developed through the various CmUs; they are:

- Data Visualisation & Journalism
- Analytics & Computational Modelling
- Applied Artificial Intelligence
- Data Administration & Management
- Analytics with Programming
- Data Strategy & Design
- Emerging Technology & Applications
- Business Needs Analysis & Strategy
- Data Security & Governance

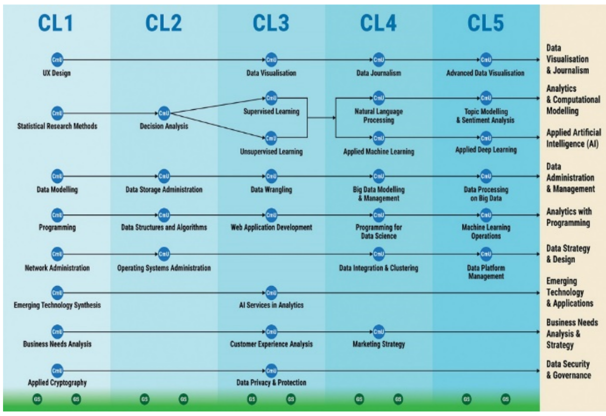

Figure 7: DBA's 9 major course competencies and associated CmUs

Related and suitable CmUs within the DBA programme are grouped, with a WIU, to form competency canvases. The DBA programme has 5 Competency Canvases listed below and illustrated in the DBA Competency Map in Figure 8:

- Visual Analytics Canvas
- Predictive Analytics Canvas
- Text & Social Analytics Canvas
- Big Data Management Canvas
- Applied AI Canvas

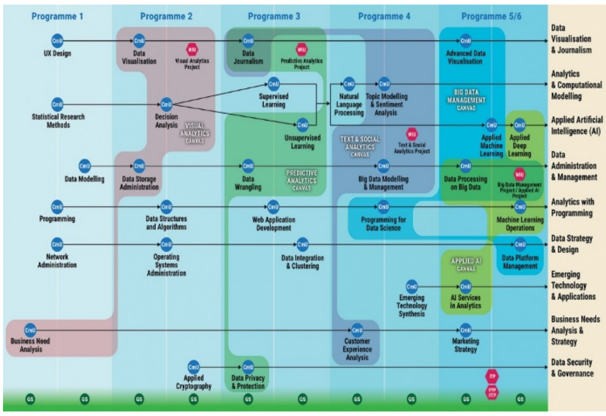

Figure 8: DBA Course Competency Map with Canvases

For example, the Visual Analytics Canvas enables the learners to synthesise the competencies developed through the set of related CmUs (Data Visualisation, Decision Analysis, Data Storage Administration and Business Needs Analysis) to carry out the following business decision support tasks.

- Perform data aggregation, modelling and mining to generate insights from raw business data.
- Present insights through real-time dashboards for visualisation that address business imperatives and needs to support decision making for business purpose.
- Perform market scanning and synthesis of big data trends, analytics platforms & tools, and emerging technologies to address business needs for analytics.

Results and Discussion

With the pilot implementation of NYP-PCM in DBA in academic year 2021, learners' feedback and their learning experiences on the competency-based curriculum were gathered using the polyechnic's Module Evaluation Feedback System (MEFS). The following is a summary of the survey result:

- About 90% of learners appreciate having different disciplinary knowledge covered within a curricular unit.
- About 86% of learners agree that the PCM-based curriculum has grown their interest in the topics they learnt
- About 89% of learners agree that the curriculum has prepared them for future jobs/studies/career paths.

The survey result has reaffirmed that there is an improvement in the new way of teaching in terms of interdisciplinary curriculum, collaborative experience, interest in learning, learners' confidence in applying the knowledge and skills they have learnt and future skills readiness. Course feedback collected from MEFS has also shown an improvement in learners' rating with regard to curriculum delivery. Learners find that the interdisciplinary learning materials were effective in helping them to learn and understand the various topics in the curricular units.

Feedback and endorsement were also solicited from IT industry. Their feedback is that the competency-based curriculum enables learners to more effectively develop the competencies and skillsets needed by industry and that it is well-positioned to train AI and data analytics professionals in developing solutions across different sectors and industries. In addition, the support and endoresement from the IT industry comes in the form of the co-creation of the curriculum where the IT industry leaders will co-develop, co-teach and co-certify the learners together with our faculty members. As such, learners can receive the following additional IT professional certificates that will be co-certified with industry leaders such as Microsoft, SAS and Oracle Academy upon successful graduation from DBA.

- Certificate of Competency in Visual Analytics jointly issued by NYP and Microsoft
- Certificate of Competency in Predictive Analytics for Data Science jointly issued by NYP and SAS
- Certificate of Competency in Database Design & Administration jointly issued by NYP and Oracle Academy.

On the univeristy front, the competency-based curriculum has garnered positive feedback from the local autonomous universities that it a forward-looking learning model. They have recognised this diploma for entry to their IT and data analytics related degree programmes and are prepared to discuss to offer additional credit exemption for the first graduating cohort in 2024.

Conclusions

The encouraging comments and positive feedback from various stakeholders in the successful piot implementation of NYP-PCM in DBA has affirmed key benefits of this competency-based learning model that aims to reimagine and transform the technical education:

- agile competency-based laerning model
- workplace practice-focused with integrated interdisciplinary learning
- multiple entry/exit with RPL and micro-credentialing
- intrinsic support for lifelong learning
- enhanced productivity through CmUs reuse based on develop-once-use-many-time scheme
- achieve flexibility and adaptability for course conduct and institutional operations.

The NYP-PCM fundamentally transforms teaching and learning in DBA with an adaptive and an agile curriculum model that is able to respond quickly to industry's needs and changes to better prepare learners in the SkillsFuture era. This interdisciplinary competency-based learning model mirrors workplace practices and intrinsically supports the lifelong-learning continuum. It benefits learners who develop competencies for work and life more effectively and maximises the potential of every learner through flexibility in their learning pathways.

The PCM model has proven to be effective from the learners' and educators' perspectives, as well as being strongly endorsed by industry and the universities. Moving forward, all PET programme in the School of Information Technology, Nanyang Polytechnic will be using the PCM by 2025.

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Learning Safety Contents through Service-Learning in an Engineering Curriculum

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Abstract

Safety has been an integral part of any engineering curriculum where students would learn the significance of safety in delivering a quality technical product or service. As an engineering professional, it is not only important that any product or service rendered is safe to protect their users, it is also an ethical responsibility of the profession. In Singapore, the safety skills and knowledge have become more pronounced with the introduction of the national Skills Framework for the various engineering sectors (SSG Skills Framework, 2022) where safety has become recognised as technical skill competencies. It is important that safety must not be learnt as knowledge only, but it should become a habit and skill that students need to embrace for their future workplace.

In the School of Engineering of Ngee Ann Polytechnic, a Year 2 module was identified to develop students with safety competencies. A service-learning approach was adopted in the design of this module, where students would work with community partners in proposing engineering solutions with safety considerations for issues highlighted by the community partners. During the engagement with community partners, students would have the opportunity to apply their content knowledge about safety in the real-world context and how the awareness of safety has real impact on the community. The effectiveness of the safety programme was evaluated through a survey that was conducted for all Year 2 engineering students who participated in the safety programme. Particularly, learners were asked to rate their learning experiences on two main aspects of the programme, namely; knowledge and awareness of workplace safety, as well as implementing a risk management plan for their pre-assigned community partner.

The results from the survey show that the students have not only acquired the necessary safety skills and knowledge, they were also able to apply them in a real-world context in service of identified community needs. In addition, the students are assessed for their safety competency and earn a national safety certification when they are able to demonstrate their attainment of certain level of safety competency.

Keywords: *Applied learning, engineering curriculum, safety, service-learning, Skills Framework*

Introduction

The School of Engineering (SOE), Ngee Ann Polytechnic (NP) aims to equip students to build a better world through a broad-based and multidisciplinary approach in 8 diplomas courses. The engineering diploma is a 3-year programme which seeks to develop work ready graduates who have acquired relevant industry skills and are knowledgeable about emerging technologies in the sector. The curriculum is also designed to enable students to have an authentic learning experience through engagement in real-world projects and develop engineering solutions that can benefit society through Service-Learning.

Whilst there are a number of engineering specialisations, safety is a common skill and knowledge for any engineering student to acquire. Safety has been an integral part of any engineering curriculum where students would learn the significance of safety in delivering a quality technical product or service. As an engineering professional, it is not only important that any product or service rendered is safe for their users, it is also an ethical responsibility. There are several instances reported in local media where failure to ensure safe installation and usage of equipment can result in loss of lives. For example, the Tuas factory explosion where the blast that injured 10 workers, of whom three later died (The Straits Times, 22 Sep 2021 & 28 Sep 2021) and the death of 3 family members by electrocution due to their water heater being installed in unsafe manner (The Straits Times, 22 Sep 2021 & 28 Sep 2021). Therefore, equipping students with the necessary skills and knowledge about safety is critical to any engineering graduate.

In Singapore, the safety skills and knowledge have become more pronounced with the introduction of the national Skills Framework in the Year 2016 for the various engineering sectors (SSG Skills Framework, 2022). Some safety related technical skill competencies

can include Workplace Safety and Health (WSH) Management and Risk Management. However, it is critical to note that safety must not be learnt as knowledge only, but it should become a habit and skill that students need to embrace for their future workplace.

This paper will elaborate of how a Year 2 module was identified to develop SOE students with safety competencies and mindset through Service-Learning (S-L). The paper will also provide insights to the students' overall learning experiences and assess the benefits of S-L in comparison to traditional textbook examples.

Infusing Safety into Engineering Education through Service-Learning & Signature Pedagogy in the Profession (SPiP)

S-L has been NP's signature pedagogy since 2016. This learning approach enables students to apply their academic learning in an organised service activity that must meet identified community needs. Students are required to reflect on the service activity in such a way as to gain further understanding of course content, a broader appreciation of the discipline and an enhanced sense of personal values and civic responsibility (Service-Learning in Ngee Ann Polytechnic, 2020). All NP students take at least one domain-specific module infused with S-L experience where they apply their course skills and knowledge to address community needs.

Therefore, when infusing safety content into a core engineering curriculum, it was designed to leverage on S-L and to allow for learning to engage in three aspects, **Head** Learning, **Heart** Learning, and **Hands** Learning.

Head Learning is the knowledge acquisition process that can include perception, memory, imagination, thought and language. The cognitive domain is usually described "as what we know", but it is in fact determined by content, understanding, analysis, synthesis and evaluation (Gazibara, 2013).

Heart Learning is not only a mental process but that it is also influenced by feelings. Emotions stimulate learning and determine whether a person is confident in his/her learning. Only when there are strong feelings about it, does a person believe something and gives significance to it which leads a mindset shift (Gazibara, 2013).

Hands Learning is suitable for 85% of learners as they are kinaesthetic learners (Gazibara, 2013). Kinaesthetic learners use body movement and interact with the environments when learning. To better understand something, they need to touch or feel it. Thus, practical information is usually preferred over theoretical concepts.

This deepens their learning, develops them personally and professionally, fosters in them a sense of service beyond self and inspires them to become a force for good in society.

Implementation of Head, Hands and Heart Learning

(i) Head Learning (Online Learning Package)

The ESAF materials are equivalent to the BizSAFE Level 2 certification which is a nationally recognised capability building programme designed to help companies build Workplace Safety and Health (WSH) capabilities. This is a 5-step programme that guides companies towards the "safety" starting from top management demonstrating their commitment towards WSH, to acquiring risk management capabilities and implementing a WSH management system as shown in Figure 1 (Workplace Safety and Health Council, 2022a).

Figure 1: The 5-step BizSAFE programme.

With reference to WSHC's Curriculum, Training and Assessment Guide for the course entitled 'Develop a Risk Management Implementation Plan 2022', relevant learning materials are curated. In order to contextualise the learning materials for SOE students, articles from local news are incorporated as part of their learning materials. For the BizSAFE Level 2 certification, there are 8 Performance Statements (PS) and 16 Underpinning Knowledge (UK). In addition, a total of 16 learning hours is recommended that includes the lesson delivery and assessment (Workplace Safety and Health Council, 2022b).

A mapping between BizSAFE Level 2 requirements (i.e., 16 UK and 8 PS) and the ESAF learning materials

and assessment was formulated to ensure all the former's requirements are fulfilled as illustrated in Figure 2. Do note that as ESAF Lesson 1 provides the linkage between ESAF and the IRP module which is not directly relevant to BIZSAFE Level 2 requirement.

An online learning package was designed to aligned to BizSAFE requirements. The simple online package included voice-over PowerPoint recordings with self-evaluation quizzes to ensure that students have grasped the key points of these lessons. This package is accessible via to NP's learning management system. Students were not allowed to advance to the next lesson until they clear the preceding lesson's quiz. After completing the required number of lessons, students would then have acquired sufficient knowledge to embark on their S-L assignments in their group. Regardless of which project they undertake, students are expected to design & present a risk management plan using their knowledge acquired via this training package.

Each student was expected to clear a total of 6 quizzes in the online package. Based on the first intake, a high passing rate of 98.7% (590 of 598 students) shows that the students have acquired the necessary head learning.

(ii) Hands Learning (Risk Management Plan, S-L in action)

In ESAF, the students worked in groups with their assigned community partners on engineering projects or matters which includes risk management plan for a key component of the project. Through this, students were given the opportunity to apply their "head learning" of ESAF materials into a real-world issue faced by the community. Table 1 shows the S-L activity with the respective community partners for each of the 8 SOE courses.

Students are assessed on 2 aspects in their risk assessment plan within the project – namely the accuracy in completing the risk assessment form and the safety insights provided to the community partners through a group presentation. For the risk assessment form, students were assessed on their ability to identify the type of hazard linked to an activity, evaluate the risk with a given matrix and if additional safety measure is required.

For the group presentation, the students would be required to share a risk management plan based on what they have observed in a risk assessment form and the different types of communication tools (such as posters and labels) prepared for the community partners. Community partners would share their perception of the presentation and provide students with feedback on their proposal. The ability to use the correct concepts learnt from the online package and communicate it effective to the end users demonstrate the ability of students to contextualise their learning and also through this process discover how their "head knowledge" has real impact on the community. The positive feedback from the community (3.78 out of a 5-point rating) indicate the "achievement" of the community partners goal. The following are two examples of how "safety" was incorporated into the projects.

Table 1: S-L activity with each community partner.

Course	S-L Activity
Electronic & Computer Engineering	Safety of workers in the green houses through IoT environmental sensors.
Mechanical Engineering	Safety in the design of rehabilitation tools for the elderly.
Electrical Engineering	Engage families to share about electrical safety.
Biomedical Engineering	Safety considerations for migrant workers' work and living environment.
Automation & Mechatronic Systems	Safety in the design of IoT solutions for families with disabilities members.
Aerospace Engineering	Building a glider with safety features to reach out to children from less privileged backgrounds.
Engineering Science	Safety for roof-top gardening through IoT applications.
Marine & Offshore Technology	To incorporate hazards and safety communication tools in the outreach purposes of WWS.

(a) S-L Activity: Electrical Safety Tips with Northwest Community Development Council

The Electrical Engineering course had partnered Northwest Community Development Council (CDC) in their S-L activity. The Northwest District in Singapore comprises the following constituencies, namely; Holland-Bukit Timah, Marsiling-Yew Tee, Nee Soon, Sembawang and Bukit Panjang. The objective of the project was to create communication materials to raise the awareness of electrical safety within the community.

Efforts were made by students to reach out to the community of the Northwest CDC to provide electrical safety tips in Week 1 of the semester as shown in Figure 3. Using the knowledge acquired on the concept of risk assessment from their online package on electrical safety, students have applied their knowledge and contextualise to the domain of electrical safety. Students planned to engage families within the Northwest CDC to participate in a virtual workshop to share about electrical safety tip within their households.

Figure 2: An outreach poster to the Northwest CDC.

After the workshop, students had to review and reflect on their experience working on their project with the community partner and articulate their learnings through a written assignment. Like all S-L reflection assignments, this is aimed to relate student's academic learning through a needed service rendered to a community.

(b) S-L Activity: Rehabilitation needs with All Saints Home

The Mechanical Engineering course partnered All Saints Home (ASH) in their S-L activity. ASH comprises of 4 nursing homes in different parts of Singapore. The elderly patients in ASH need to be engaged with activities constantly to maintain their mental and physical well-being. As such, physiotherapists in all the 4 centres are in a constant lookout for solutions to better care for these patients' rehabilitation needs.

Students were introduced to ASH's mission and vision through a learning journey in Week 1 of the semester where students could find out more about the needs of the homes and the residents before they start to design suitable equipment which can assist and enable the physiotherapists to conduct rehabilitation activities with the elder patients. Throughout the design process, students were reminded of the need to ensure their designs were suitable and safe for the elderly to use.

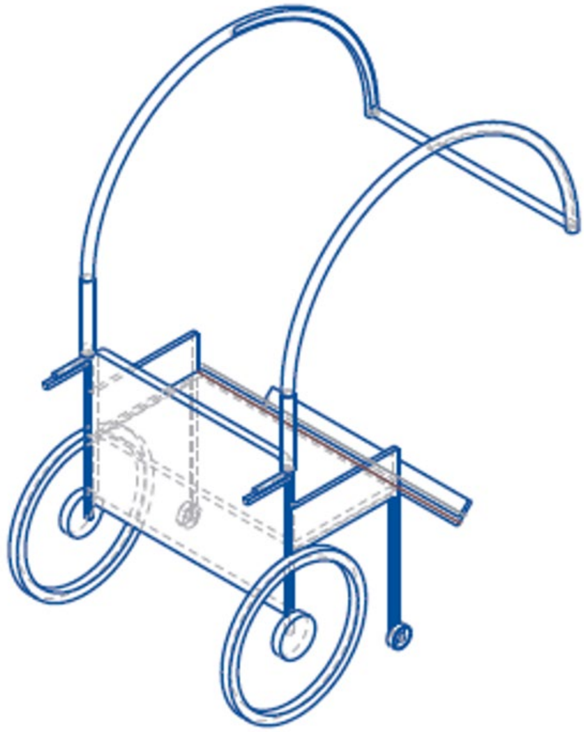

Figure 3: Students' idea presentation in a webinar where two additional wheels and an extended holding bar were added for better stability of a walking aid

Through a webinar, students' ideas were presented and shortlisted by ASH to be actualised as projects as illustrated in Figure 3.

(iii) Heart Learning (Students' Reflections on Learning)

Reflection is a crucial part of S-L as it allows students to think critically about and what has been learnt from their engagement with the community. Reflection may include acknowledging and/or sharing reactions, feelings, observations, and ideas about anything regarding the S-L activity. Reflections is a demonstration of students' thinking and an opportunity to review if there is any change in the students' mindsets or attitudes. By reflecting, this distinguishes S-L from a volunteer work and community service. In this assignment, students were asked to reflect on two aspects; personal growth outcome and civic learning outcome.

One of the key outcomes is the "safety mindset" and students would need to demonstrate how their attitudes towards "safety" has changed. Each student had to pen down personal reflections as part of their S-L experience in areas of personal growth and civic learning outcome. Based on the reflections shared, many of the students have indicate a change in mindset about the "safety" when designing a product and this is especially so when students could see for themselves how the notion of safety is not just head knowledge but has practical purpose and can be a matter of "life & death".

Below is an extracted paragraph from two different students.

"I learnt that different communities have diverse needs and strengths, and my own experience may be very different from other people. Our group met Mrs T who stays in a flat with the basic understanding of electrical safety. Hearing from Mrs T, we understand that she is more concerned that the electrical appliances do not create any hazard by turning off all the appliances when going out. However, to many of us, we have taken for granted that simple things like turning off the fan, lights to avoid physical hazard."

"I learnt that Mr O had shocked himself multiple times in the past when setting up for Chinese New Year celebrations. I am surprised that he knew some of the electrical basics but he did not practise them fully."

Effectiveness of programme

After going through their learning journey, the effectiveness of the safety programme was evaluated through a survey that was conducted for all Year 2 SOE students who participated in the safety programme. A total of 410 SOE students responded to the survey on a voluntarily basis.

Particularly, the students were asked to rate what they have learnt on two aspects using a 4-point scoring system. Firstly, they were asked to rate whether the content had increased their knowledge and awareness of workplace safety from a zero (0) indicating they have learnt nothing to a four (4) denoting otherwise. The outcome is as shown in Figure 4. From the result, 98% of the students who responded either strongly agreeing or agreeing that they have an increase in their knowledge and awareness in workplace safety which indicates a success for the programme in this aspect.

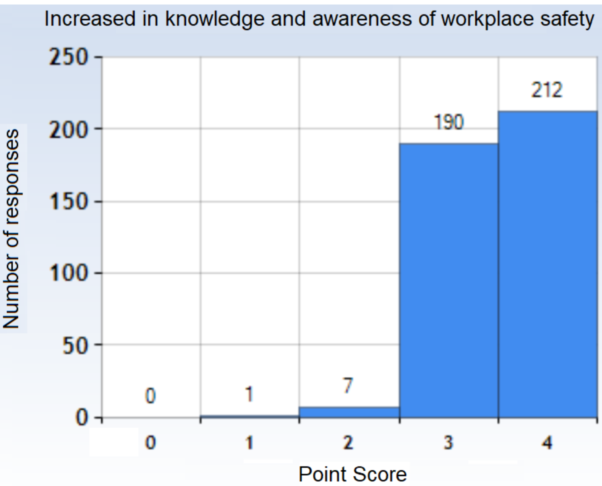

Figure 4: Students were asked to rate their knowledge and awareness of workplace safety have increased.

Next, they were also asked to rate whether the content had taught them sufficiently to implement a risk management plan in a community-based project with a zero (0) indicating that they strongly disagreed with the statement while a four (4) denoting that they strongly agreed. The outcome is as illustrated in Figure 5. Similarly, 96.1% of the surveyed students either strongly agreed or agreed that they are proficient to implement a risk management plan which means success of the programme in this aspect as well.

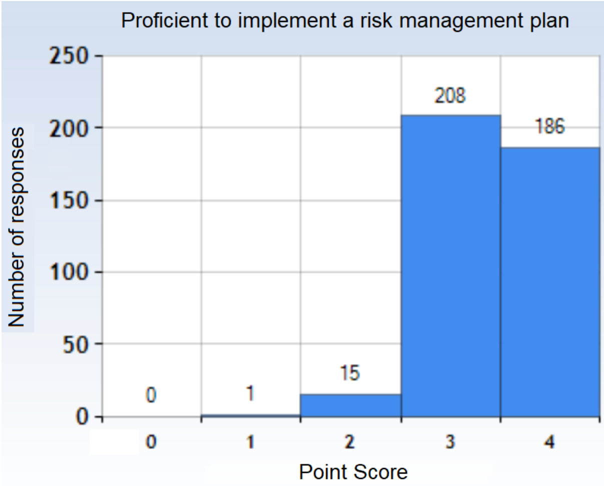

Figure 5: Students were asked to rate they are proficient to implement a risk management plan in a community-based project.

Conclusion

Thus, the Head Learning, Heart Learning, and Hands Learning has been effective as students were able to not just demonstrate their ability to use their acquired knowledge in the real world but also show a change in their mindset towards the importance of safety as an engineering professional. Safety is not just head knowledge but it is important that engineering students see it as a philosophy and part of who they are as a professional. In addition, the students were assessed for their safety competency and would have also earned a national safety certification when they were able to demonstrate their attainment of a certain level of safety competency based on the BizSAFE Level 2 certification requirements.

Acknowledgements

We would like to acknowledge the kind support of our community partners in providing a real-world community-based learning experience for our students.

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Practice report of distance learning between Japan and Malaysia using Information and Communication Technology

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Abstract

The National Institute of Technology (KOSEN) provides intensive lectures at the INTEC Education College of KOSEN Preparatory Course for international students who are scheduled to be sent by the Malaysian government. The author was in charge of Information Fundamentals I in the 2020 and 2021 academic years. In previous years, intensive lectures were held at INTEC College of Education in Malaysia, but this year, due to the spread of coronavirus infection, the lectures were conducted remotely. This presentation is a report on the educational practice of remote lectures, in which a teacher provides the lectures from Japan (Ichinoseki City, Iwate Prefecture) using ICT technology, and the students attend the lectures in Malaysia. The syllabus for Information Fundamentals I includes three sections: Information Mathematics, which is a classroom lecture, and Excel Fundamentals and C Language Fundamentals, which combine classroom lectures and practical training. In conducting the remote class, we combined cloud services such as zoom, slack, Microsoft Teams, youtube, and AWS, but there were three issues to be addressed. First, there was the problem of the viewing environment. Second, there is the issue of the time difference. Finally, there is a difference in the exercise environment in which the c-language training is conducted.

To address these issues, the video size was reduced so that the viewing environment would not be overloaded even in low-speed communication environments. Additionally, since a certain number of students were viewing the lecture on mobile phones with small screens, the text on the slides was made larger.

Regarding the issue of time difference, the combination of the on-demand type and the on-demand type made it possible for students to view the lectures at their convenience. Regarding the last OS difference, we could reduce the impact of OS differences by preparing a c-language compilation environment on AWS.

Additionally, when we checked the viewing status of the class videos using the youtube analysis function, we found that the video viewing time per session was quite short, at just under 5 min.

Keywords: *distance learning, ICT, cloud service, remote class, global education*

1. Introduction

KOSEN offers a preparatory course (KUMPULAN TEKNIKAL JEPUN, hereafter KTJ) for international students dispatched by the Malaysian government. This report describes the distance learning courses conducted in FY2020 and FY2021 in this course.

1-1.About KTJ

KTJ is a two-year course for students who wish to transfer to the third year of KOSEN. In addition to Japanese, mathematics, physics, chemistry, and English, students study basic information science. The content of the course includes basic information mathematics and programming, which are studied in the first and second years at KOSEN, and Microsoft Excel, which is used to prepare reports on assignments, etc. This report describes the implementation of Information Fundamentals I, which the author was in charge of. The syllabus and other details will be described later.

1-2.Changes in FY2020 and FY2021

Information Fundamentals I has been conducted in an intensive lecture format in early January every year, but due to the spread of the new coronavirus infection that began on a global scale in early 2020, it was difficult to conduct face-to-face classes in Japan and Malaysia. Therefore, it was decided to conduct the program in an on-demand format in FY2020 and in a remote, intensive lecture format in FY2021. The following issues arose due to the implementation of classes from remote locations.

1-2-1. Viewing environment issues

Many students take the course from home, but due to various communication environments, such as fiber-optic and mobile network, the communication speed is not constant. Therefore, there is a concern that video playback will not be smooth in a low-speed environment for content that is too large in data volume.

Additionally, 17.4% of students in FY2020 and 12.1% in FY2021 were viewing videos on mobile phones. In some cases, it is difficult to read text and other information on mobile phones because the screens-displaying videos are smaller than those of PCs.

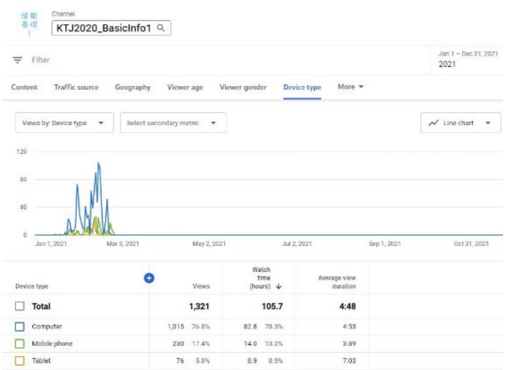

Figure1.YoutubeAnalyzer-Device of FY2020

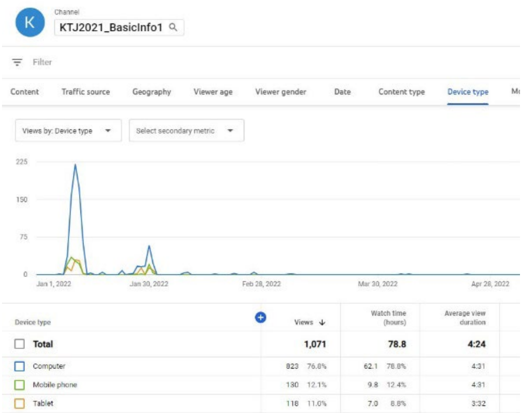

Figure2.YoutubeAnalyzer-Device of FY2021

1-2-2. Time Difference Issues

There is a time difference between Japan, where the video is delivered from, and Malaysia, where the video is viewed from, with Japan being one hour ahead of Malaysia. In the case of an intensive lecture format, it is necessary to consider the local rhythm of life, such as lunch time.

1-2-3. Problems with the exercise environment

In Information Fundamentals I, there is a practical training for creating programs in the c language, and some students used different PCs, such as Windows and MacOS, and some used tablets and ChromeBooks.

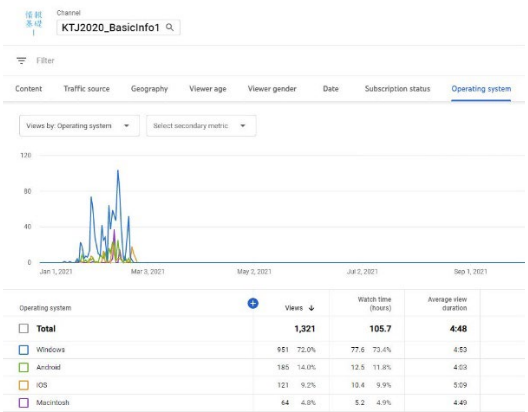

Figure3.YoutubeAnalyzer-OS of FY2020

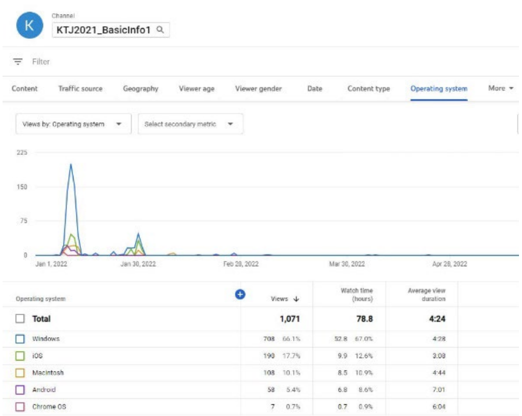

Figure4.YoutubeAnalyzer-OS of FY2021

2. Methods

2-1. about the subjects to be implemented

In this section, the contents of Information Fundamentals I are presented.

2-1-1. Syllabus

The syllabus is as follows

Spreadsheet:

To acquire the basic operations of the spreadsheet software Microsoft Excel.

Use of spreadsheet software
Input, correction, and deletion of data
Creation of calculation tables

Functions:

Acquire how to use functions of Microsoft Excel spreadsheet software.

SUM, AVERAGE functions
MAX, MIN, RANK functions
VLOOKUP function

Database:

Acquire operations such as sorting data in spreadsheet software MicrosoftExcel.

Overview of databases
Sorting records

Graphing:
Learn to create graphs from spreadsheets in Microsoft Excel.
Creating and Editing Graphs
Types of Graphs
Compound graphs

Data Linkage:
We learn to embed spreadsheets and graphs from MicrosoftExcel in MicrosoftWord documents.
Use as word processing software
Paste tables and graphs into word processing software

SIN and CON functions:
To master the use of SIN and COS functions in Microsoft Excel spreadsheet software.
SIN, COS Functions
Use of SIN and COS functions

Information Representation:
Understand binary numbers and how to express negative numbers and decimals in binary.
Notation of place value, binary and decimal numbers
Representation of negative number
Representation of binary decimals and real numbers

Programming:
Understand how to create computer executable programs in c language.
Programming Mechanisms
Simple programming
Compilation and compilers

Console:
Acquire console input/output methods in c language.
Console output (printf())
Console input (scanf())

Variables, data types, and constants:
Understand variables, functions, and constants in the c language.
Variables and functions (how to add identifiers)
Variables
Data types
Constant expressions (numeric constants, character constants)

2-1-2. Achievement objectives

Based on the syllabus in 2-1-1, we have summarized the three objectives of practical training.

Handling of information on computers:
Binary numbers, hexadecimal numbers, data ordinates (K bytes, M bytes, etc.)

Spreadsheet:
To understand the basic operations of spreadsheet software and be able to create documents that include tabulation functions, etc.
Basic operations, functions, graphing, database functions (query, sort, filter)

Basic Programming:
Concepts of executable programs that run on computers, how to create executable programs (compilation), creating simple programs (variables, functions, constants, input/output)

2-1-3. Rubric

The following rubric was created based on the achievement goals in 2-1-2.

Objectives	Ideal Level	Standard Level	Unacceptable Level
Handling information on computers	Can perform binary arithmetic operations and place value without assistance	Can perform binary operations and place values with some assistance	Cannot perform binary operations and place values
Spreadsheet	Can create documents using spreadsheet software without assistance	Can create documents using spreadsheet software with some assistance	Cannot create documents using spreadsheet software
Basic Programming	can create simple executable programs without assistance	can create simple executable programs with some assistance	Cannot create simple executable programs

Table1. Rubric

2-1-4. Evaluation method

Assignment/Homework (40 points x 2):
Creation of documents using Excel
Programming using C language

Quiz/Mini Test (20 points):
Binary/hexadecimal number calculation, place value writing, terminology check

2-1-5. Educational methods

The following tools were used in FY2020.

Slack: Links to class videos and other information will be posted. Slack will also be used for questions.

YouTube: Distribute class videos.

The following tools were used in FY2021.

Teams: Post links to class videos, contact information, etc. Also, questions will be accepted on Teams.

YouTube: Distribute class videos.

2-2. Implementation Details

2-2-1. for FY2020

In FY2020, due to the lockdown caused by the spread of coronavirus infection, it was difficult to conduct practical training in a group setting; so it was conducted in an on-demand format.

The video delivery schedule was decided to be released every week in consideration of the flow of the practical training.

Lecture1 25/Jan/2021 Handling Information with Computers

Lecture2 1/Feb/2021 Excel Basics

Lecture3 8/Feb/2021 c language basics

The following tools were used in class.

Slack for communication, questions, etc.

Distribution of class videos: Youtube

Quiz: Microsoft Forms

2-2-2. for FY2021

In FY2021, compared with FY2020, coronavirus infection has subsided, and except in some areas where the infection spread, it was possible to conduct practical training in the assembly, so intensive lectures were conducted according to the following schedule.

10/Jan/2022-14/Jan/2022

The following tools were used in the classes

Microsoft Teams for communication and questions

Youtube for class video streams

Online class delivery: Zoom

Quiz: Microsoft Forms

3. Results and Discussion

The following considerations were made for the issues mentioned at the beginning of this report.

3-1. Considerations for the viewing environment

3-1-1. Reduction of video data volume

In consideration of the viewing environment where communication speeds are too slow, the video size was reduced to reduce the amount of communication data. The practical training in this course does not require detailed movements, such as manipulating Excel or compiling and executing C. The lectures did not require detailed movements. Similarly, lectures do not require detailed movements.

Therefore, to reduce the volume of communication data, the number of frames in the video was reduced and the movements were made coarser to reduce the data volume. The bit rate was also reduced for the audio of the video since high resolution is not required and it is sufficient to be able to hear what is being said. However, the resolution of the video was not reduced because there was concern that the text on the slides would become difficult to read due to the coarser images.

The actual video file size was reduced from 0.54 MB to 0.10 MB per second by reducing the number of frames and the bit rate of the audio using video editing software. Cyberlink PowerDirector19 was used as the video editing software.

Original video	After file size reduction
Video Resolution:1920x1080 FrameRate:29.97/sec	Video Resolution:1920x1080 FrameRate:15/sec
Audio Bitrate:395bps SamplingRate:48kHz	Audio Bitrate:63kbps SamplingRate:48kHz
FileSize:0.54MB/sec	FileSize:0.10MB/sec

Table2. Parameter of video converting

Below is the PowerDirector editing screen.

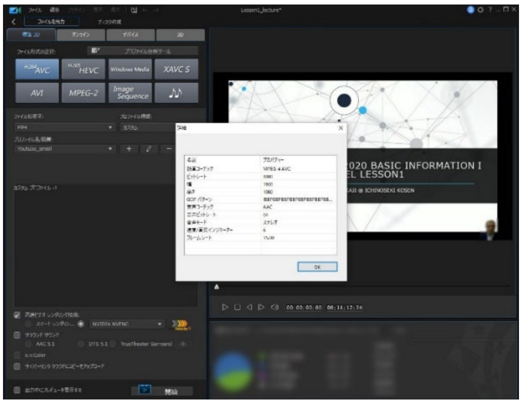

Figure5.Video converting screen

3-2. Consideration for time differences

In FY2020, the videos will be in an on-demand format, allowing students to view the videos at their convenience.

In FY2021, although it will be in a group format, it will be combined with on-demand materials so that students will be able to view the videos at their own convenience to some extent.

In both years, SNS tools were used so that students could easily ask questions at any time, but some concerns were found: in MicrosoftTeams, students were registered as guests on private teams, but files could not be attached when posted by the guests. Therefore, in FY2020, students could submit assignments via slack, but in FY2021, assignments were submitted via e-mail. It would be easier for both faculty and students if comments and other information on the submitted assignments

could be added via SNS tools, so that communication could be managed centrally.

3-3. Consideration for exercise environment

MinGW installation was not easy because of the special drive configuration. A question asked was about the MinGW path settings were unclear due to the special drive configuration.

In FY2021, some students used Chromebooks in addition to Windows and MacOS, making it difficult to install gcc locally. Additionally, several students had difficulty installing gcc in FY2020, so in FY2021, we decided to create an EC2 on AWS and have the students to connect to it via ssh.

Windows) Using ssh command on PowerShell

MacOS) Using ssh command on the terminal

iPadOS) Install Shelly from the AppStore and use it to connect via ssh

Chromebook) Install SecureShellApp from the chrome web store and use SecureShellApp for ssh connection

The method used in FY2020 to install the compilation environment on terminals was time-consuming to support since the terminals were remote and students had access to different terminals. However, with the method for preparing the compilation environment on EC2 on AWS, students only needed to prepare an ssh connection, and it is thought that they could engage in the exercise quickly.

3-4. Other Considerations

3-4-1. Dividing the Video

During the Corona Disaster, students had some comments that the long online class at Ichinoseki National College of Technology was tiring for their eyes, so we decided to divide the video of this course into small segments of about 20 min at the longest. The reason for setting the maximum length at 20 min was that this amount of time was coherent enough for the explanation of each item.

The viewing status after the class was conducted was checked using YoutubeAnalyzer.

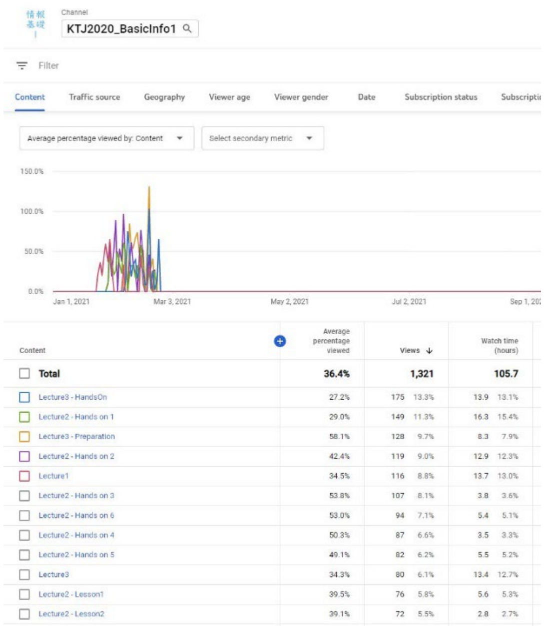

Figure6.YoutubeAnalyzer – Contents of FY2020

Video name	Video Time(sec)	Average percentage viewed	Viewing time per session(sec)
Lec1	1,235	34.5	426.1
Lec2-1	673	39.5	265.8
Lec2-2	364	39.1	142.3
Lec2-3	1,357	29.0	393.5
Lec2-4	926	42.4	392.6
Lec2-5	236	53.8	127.0
Lec2-6	290	50.3	145.9
Lec2-7	494	49.1	242.6
Lec2-8	392	53.0	207.8
Lec3-1	403	58.1	234.1
Lec3-2	1,757	34.3	602.7
Lec3-3	1,050	27.2	285.6
Average			288.8

Table3. Contents of FY2020

The average viewing time per session was 4 min 48 seconds in FY2020.

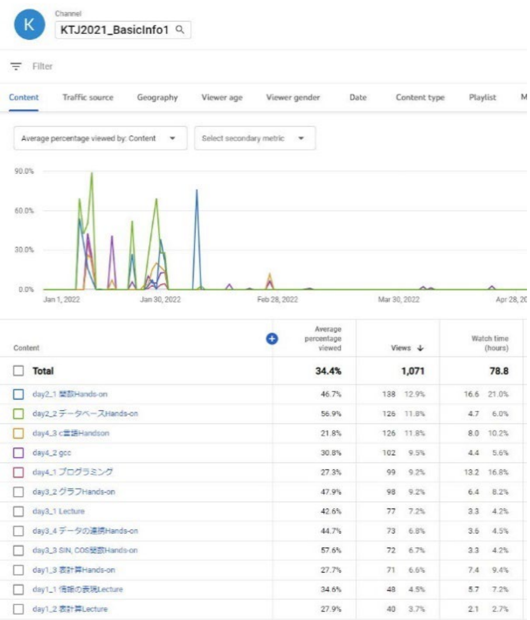

Figure7.YoutubeAnalyzer – Contents of FY2021

Video name	Video Time(sec)	Average percentage viewed	Viewing time per session(sec)
Lec1-1	1,235	34.6	427.3
Lec1-2	673	27.9	187.8
Lec1-3	1,357	27.7	375.9
Lec2-1	925	46.7	432.0
Lec2-2	236	56.9	134.3
Lec3-1	364	42.6	155.1
Lec3-2	494	47.9	236.6
Lec3-3	290	57.6	167.0
Lec3-4	392	44.7	175.2
Lec4-1	1,757	27.3	479.7
Lec4-2	507	30.8	156.2
Lec4-3	1,050	21.8	228.9
Average			263.0

Table4.Contents of FY2021

The average viewing time per session was 4 min 23 seconds in FY2021.

The maximum length of the videos was set at 20 min due to the convenience of the training items, but the average viewing time per video showed that students were viewing the videos in short intervals of about 5 min. A study (Abe, 2021) 1 recommends that the length of videos should be maintained within 10 min to prevent students from losing their concentration.

However, if the videos are too detailed, students will have to switch to the next video when viewing. Therefore, a possible method is to use Youtube video chapters where there is a good 5 to 10 min break.(YouTubeHelp Video chapters)

3-4-2. Security considerations

The class videos are produced independently, so there are no copyright issues. However, the videos were made available to the public on Unlisted videos so that only students could view them through google searches, etc. Unlisted videos is a Youtube function that allows only those who know the link to view the video.(YouTubeHelp Unlisted videos)

4. Conclusions

In the implementation of this teleclass, several cloud tools were used, and although some points needed to be improved, it was found that the classes could be conducted effectively enough.

The following is a summary of the actions taken in the implementation of this class.

1) The video frame rate and audio bit rate were changed to reduce the size of the video order to reduce the amount of communication data.
2) The text size of the slides was increased in consideration of viewing on mobile phones with small screens.
3) The video was made available in an on-demand format so that students could view it at their convenience.
4) The C compile environment was prepared on AWS to allow for the mixing of different operating systems.

Although it was impossible to implement this project this time since each viewing time was approximately 5 min, it is possible to include chapters in the class video at intervals of 5 to 10 min, as appropriate, so that students can view the video at appropriate intervals.

Here, the remote class was conducted using familiar cloud tools already used, but other useful services are thought to exist. By using these services, effective remote learning can be implemented.

5. Acknowledgments

I want to thank Mr. Abdul Halim Mamat of INTEC Education College for his kind permission for this presentation.

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YouTubeHelp Unlisted videos from https://support.google.com/youtube/answer/157177#unlisted&zippy=%2Cunlisted-videos

YouTubeHelp Video chapters from https://support.google.com/youtube/answer/9884579?hl=en-GB

Design education using 3D-CAD/CAE on vibration engineering

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Abstract

Our department (department of mechanical engineering) has been experimenting with a new design program "Manufacturing education utilizing 3D-CAD". In the program, the purpose of this subject is not to teach 3D-CAD/ CAE operation but to enable mechanical design using 3D-CAD/ CAE for students. we will focus on vibration engineering. We attempt to focus on vibration engineering.

First, the students will learn the basics of vibration phenomena. The natural frequency of a uniform bar is calculated according to the formula described in the textbook. In addition, The boundary conditions are given to the uniform bar designed by 3D-CAD, and simulations are performed to obtain eigenvalues. Then, the natural frequencies are found by vibrating the machine. The purpose of this study is to understand by comparing textbooks with simulations with real phenomena.

Next, each student designs an optimum structure under given criterion. A competition by the students is held to select the best structure from modal analysis. The selected model is then improved in each group by discussion.

Finally, the structure is actually tested using experimental apparatus and compare and study the simulation results. This allows students to learn about vibration phenomena, theories, and why errors occur. Through this program, students can feel the vibration more clearly.

Keywords: *CAD/CAE, design education, vibration engineering,*

1. Introduction

Vibration engineering in mechanical mechanics is an important part of mechanical mechanics. In dealing with vibration, natural frequencies and vibration modes are important. This is because the displacement increases due to resonance and the structure cannot be maintained. In vibration engineering, it is clarified that there is a natural frequency and vibration mode related to each frequency in every structure, but first, in the curriculum, the classroom teaches 1 degree of freedom, 2 degrees of freedom, n degrees of freedom, natural frequency of the continuum, and natural mode of the natural mode. By running a simple simulation program, it helps to understand the resonance phenomenon.

Next, since mechanical structures are continua, understanding of vibration phenomena and wave equations of continua will be taught in class, and eigenvalue analysis (modal analysis) using CAD/CAE will be performed to promote understanding.

Here, the students will not only perform CAD/CAE operations, but also design. The outline is as follows.

1) Learn the fundamentals of vibration through simulation.
2) Create a model of a uniform bar with a weight attached and compare it with the actual machine.
3) Build a two-layer model and simulate it.
4) Group discussion to select a preferred model
5) Conduct experiments on the actual machine and compare the results with the simulation results.

Students will build a 3D model to minimize the natural vibration of mode 2. The model is actually assembled, and vibration tests are conducted to compare the results.

The results of questionnaires by students are also included.

2. Modal analysis using 3D-CAE

In dealing with vibrations, the basic system is a one-degree-of-freedom vibration system. The theory was taught in classroom lectures, and simulation programs were used to help students understand resonance phenomena. The interface screen of the 1-DOF simulation program is shown in Figure 1. This was done using Visual Basic to develop a modal analysis software including a damping term.

Figure 2 shows a screen that can simulate a modal analysis with n degrees of freedom (max n=5). This is to make the user understand that there are n natural frequencies in the case of n degrees of freedom.

Both simulation programs can simulate the fact that resonance occurs when the external excitation force and displacement match the natural frequency, and that there are differences in the way resonance occurs in the case of n degrees of freedom. It is also possible to include a damping term in the analysis.

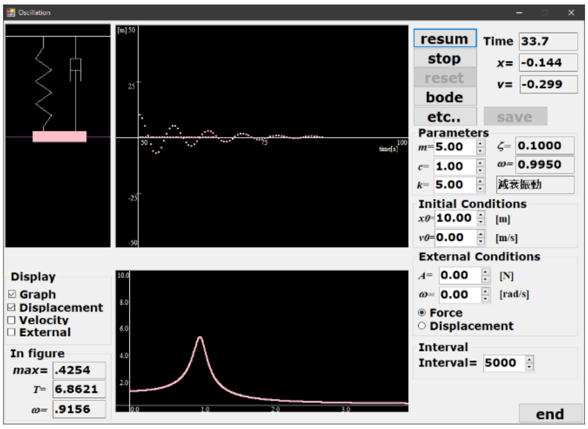


Fig.1 The 1-DOF simulation screen

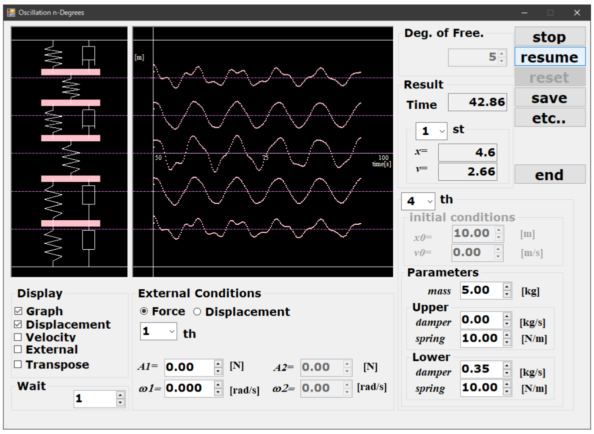


Fig.2 The n-DOF simulation screen

In modal analysis of a continuum, the equations of motion are expressed in terms of edited differential equations, and only very simple examples can be solved. Therefore, a simple model can be created in 3D-CAD software “SOLIDWORKS”, and the students can practice to see if the results of modal analysis by CAE(SOLIDWORKS Simulation) are consistent with the theoretical calculations. The modal analysis of the uniform bar is in good agreement with the theoretical solution. Figure 3 shows the results of the modal analysis.

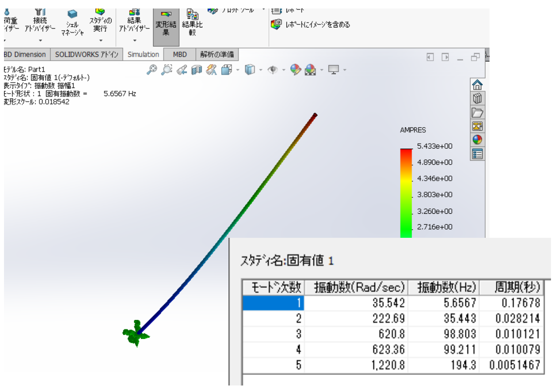


Fig.3 the results of the modal analysis.

Next, an assembly was made by attaching a weight to the uniform bar in Figure 4, and the approximate solution was compared with the CAE results. This natural frequency is expressed as

$$\omega_n = \sqrt{\frac{3EI}{ml^3}} \qquad (1)$$

where ω_n is the natural frequency, ρ is the density of the bar, E is Young's modulus of the bar, m is the mass of the weight, and l is the position of the weight.

The students were also asked to compare the results with those of the actual machine and discuss the results. Figure 5 shows the actual machine.

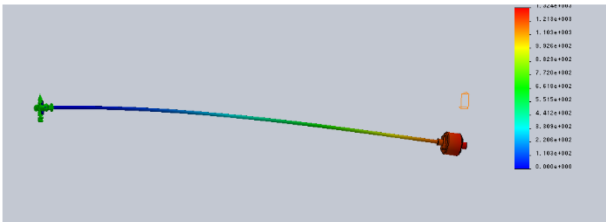


Fig.4 The attaching a weight to the uniform bar

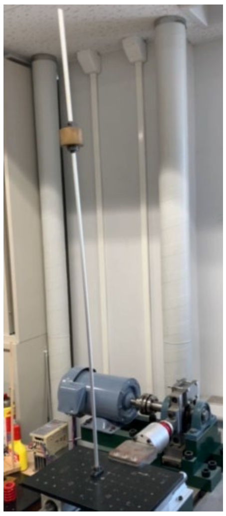


Fig.5 The actual machine

3. Design and experimentation of a two-level model

After understanding vibration phenomena and CAE, a more complex model is built. It is a two-level model, mimicking a two-story building. incomplete line; do not underline any part of the text; do not forget to check the spelling. Figure 6 shows an example of a two-level model. (a) is a high rigidity and (b) is low rigidity.

A two-layer model with two plates and several columns with two patterns was created for modal analysis. The minimum number of columns was specified to be two and 500 mm in length. Breadboards were provided for the plates on each floor to allow some modification of the column positions, and the task was to optimize the design for large and small natural frequencies.

Each student first designed a model using 3D-CAD/CAE. After each student had created the best

design, the best model was selected in each group of 8 students based on the originality of the design and the lowest natural frequency. The selected models were discussed and improved by each group and static analysis was also performed to confirm safety.

(a) High rigidity (b) Low rigidity

Fig,6 Structure of a two-level model

Figure 7 shows the simulation results and the improved model actually assembled, mounted on a shaker, and vibrated.

Overall, the experimental results were almost in agreement with the CAE analysis results. Reasons for the difference between the experiments and the analysis could be the lack of precision of the experimental equipment, inaccuracy of the 3D model, or errors in the CAE itself. Although actual phenomena cannot be accurately predicted by CAE, it is possible to feel and see the invisible and understand them more clearly in the experiments. The types of designs by the students were diverse even under the limited constraints.

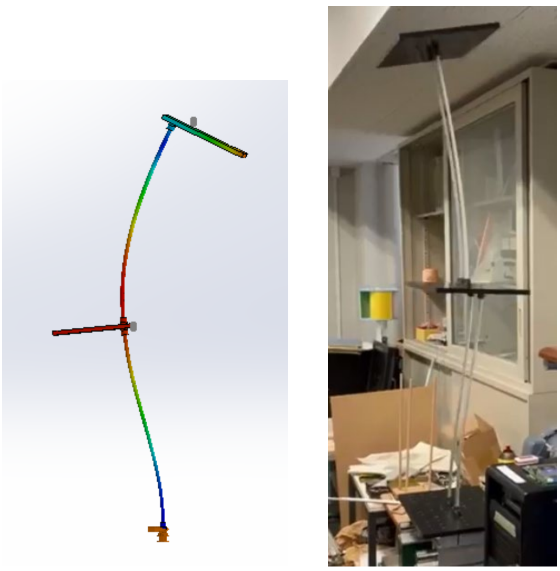


Fig.7 CAE anlysis and test

4. Results and Discussion

Figure 8 shows the results of the questionnaire for this program.

I. Relevance of the simulation to what you learned in the classroom course "Mechanical mechanics" (multiple responses allowed)

a) It matched what I learned in Mechanical mechanics

b) I could understand more deeply what I learned in Mechanical mechanics.

c)I did not understand much.

d)I could not understand at all.

II. Modal analysis of continuum (uniform bar, bar with load) and results of actual machine (multiple answers allowed)

a) The results were consistent with what I learned in mechanics.

b) I could understand more deeply what I learned in Mechanical mechanics.

c) I could understand the significance of simulation.

d) I could not understand what was being done in the simulation.

e) Manual calculations and simulation matched well.

III. Modal analysis and experimentation of the a two-level model with the actual machine (multiple responses allowed)

a) I could understand the intention and significance of the experiment.

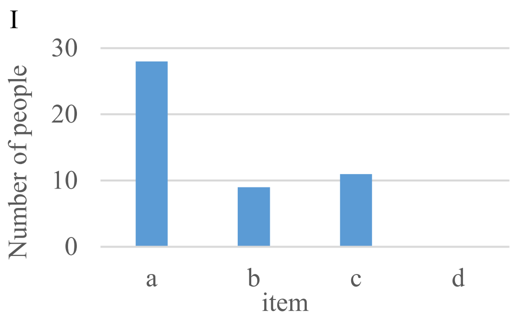
b) I could understand it in relation to the lesson of mechanical mechanics.

c) I was able to deepen my understanding further by comparing the simulation and the actual machine.

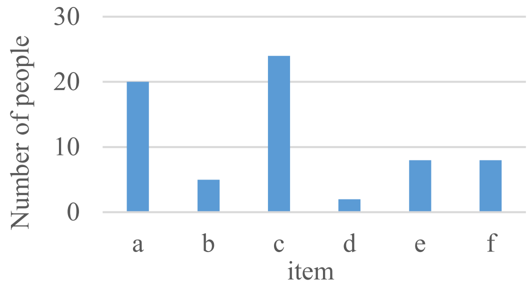
d) I could not understand what was being done.

e) I could deepen my understanding of the resonance phenomenon.

From the results of I, II, and III, it was found that this curriculum helped the students to understand. However, there are still some students who do not understand it, and more improvement is needed.



II



III

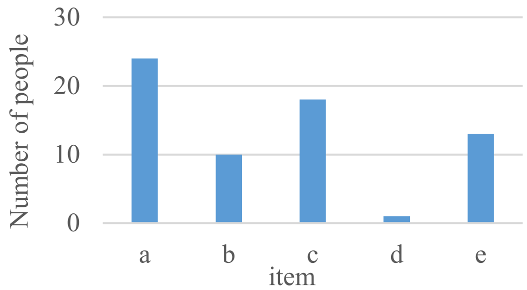


Fig. 8 Results of student questionnaire

5. Conclusions

The modal analysis was designed to help students understand the mechanism of vibration and the significance of modal analysis by utilizing Visual Basic and 3D-CAD/CAE. From the results of the questionnaire, we believe that the participants deepened their understanding of the significance of modal analysis through comparison of theory, analysis, and actual equipment. In addition, the team discussion on the optimal design contributed to the improvement of the team's capability.

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Improve Instructor Immediacy with AI Conversational Bot to Enhance Learning Outcomes

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Abstract

Studies show that instructor immediacy during learning has a positive impact on learner satisfaction (Baker, 2010), learning achievement (Montuori, 2021), and learning experience (Wendt J.L., 2018). With home-based learning becoming a pervasive feature of Singapore education to encourage more independent learning and promote lifelong skills, Institutes of Higher Learning (IHL) need to relook at how to provide virtual learning support for our learners to improve instructor immediacy. At present, learners can ask questions in the discussion forums within the Learning Management System (LMS) or send questions to their instructors by email when encountering problems during online learning and self-learning. Alternatively, the learners can wait until they are in class or when the lecturers are available to resolve any questions or doubts. Motivation is low when learners are stuck on a question and do not receive immediate support to mitigate the problem. It is crucial and timely to relook at how our teaching practices can leverage technology to provide instant support to address the increasing demand for instructor immediacy from the learners and help learners thrive in learning amidst the pervasive home-based learning environment.

This project aims to improve instructor immediacy to enhance learning achievement, motivation, cognitive engagement, and learning experience by engaging the learners in their study and empowering them to take charge of their studies using an AI conversational bot that can understand and respond to learners' queries. The conversational bot delivers tailored information in easily digestible bite-sized chunks, specific to the learners' questions. It can also suggest relevant and contextualised learning content to the learners. The AI conversational bot emphasises engaging and facilitating learners in their learning and helps them to attain better performance.

The study compares the outcomes of learning assisted with AI conversational bot against the conventional approaches (learning assisted through asynchronous platforms such as messaging and discussion forums) by measuring the learning achievement, motivation, cognitive engagement, and learning experience. The research adopts an intervention study using a quasi-experimental design with a sample size of 82 learners from 2 diplomas taking a second-year Engineering Mathematics module. The result shows statistically significant better performance for the learners in the experimental group. Both the passing rate and the number of learners who scored grade B and above are higher in the experimental group. The survey also reflects positive results on learners' motivation, engagement, and learning experience.

The findings suggest that conversational bot helps the learners grasp the concepts and learn more confidently during online learning and self-learning. Learners receive timely assistance to overcome ambiguities and build their confidence. As a result, they are motivated to keep on their learning journey. The bot is interactive and easy to use. These features also contribute to improving the learners' learning experience.

The study shows that the solution addresses the need for the instructor immediacy during learning and receives positive feedback from the learners. We can apply this solution to other modules to provide a learner-friendly environment during online learning and self-learning.

Keywords: instructor immediacy, learning support, self-learning, learning outcomes, learning experience

Introduction

Communication is essential to the learning process. One communication dynamic that influences learning is the instructor's immediacy. Studies found that instructor immediacies in an online learning environment have positive impacts on learner affective learning, cognition, and motivation (Baker, 2010). Montuori (2021) suggests that instructor immediacy plays a remarkable role in learning achievement. He pointed out that learners learn more effectively through interactions, and those who receive immediate help tend to attain better results and enjoy studying better. Wang et al. (2021) explained that questioning, and initiating discussion have a significant positive correlation with learners' cognitive and affective learning.

Davis & Antonenko (2017) suggested that chatbots are conversational agents that can facilitate learning through interactions with the learners. Not only it can provide a personalized, engaging, and result-oriented online learning environment, but it is also capable of delivering information such as study materials (Cunningham-Nelson, 2019), practice questions and answers (Sinha, 2020), evaluation criteria (Durall & Kapros, 2020), assignment due dates, and advice (Ismail & Ade-Ibijola, 2019) tailored to the needs of individuals learners (Choksey, 2004) to assist learning.

With home-based learning becoming a pervasive feature of Singapore education to encourage more independent learning and promote lifelong skills, it is timely that the Institutes of Higher Learning (IHL) relook at how to improve instructor immediacy and reduce learner's anxiety in an online learning environment.

At present, learners can ask questions in the discussion forums within the Learning Management System (LMS) or send questions to their instructors by email when encountering problems during online learning and self-learning. Alternatively, they can wait until they are in class or when the lecturers are available to resolve any questions or doubts. In both scenarios, the learners would have to wait and expect a delay in getting the answers. There is a significant time lag between message production and response. Motivation is low when learners are stuck on a question and do not receive immediate support to mitigate the problem. Baker (2010) suggested that the learners are more motivated and more confident to learn when they get immediate support to help them grasp the concepts. This is especially true for online learning and self-learning.

We need a new solution to provide immediate support to our learners. The advancement of Artificial Intelligence (AI) has unlocked new use cases to transform the learning experience among the learners.

Virtual Learning Assistant (VLA) is an AI conversational bot that can understand and respond to learners' queries. Using a two-way flow of information between a user and the back-end server, VLA responds to the learner's input and presents the response in bite-size chunks to guide him to grasp the concepts and solve the learning tasks. Using AI and deep learning, VLA can understand the learners' intent and deliver consistent and accurate information specific to the learners' queries. It can also suggest relevant and contextualised learning content to the learners. VLA comes in handy when studying and revising at home. We can integrate the VLA, as shown in Figure 1, with the existing online learning management system (LMS) such as POLITEMall to let the learners have easy access to the virtual assistant.

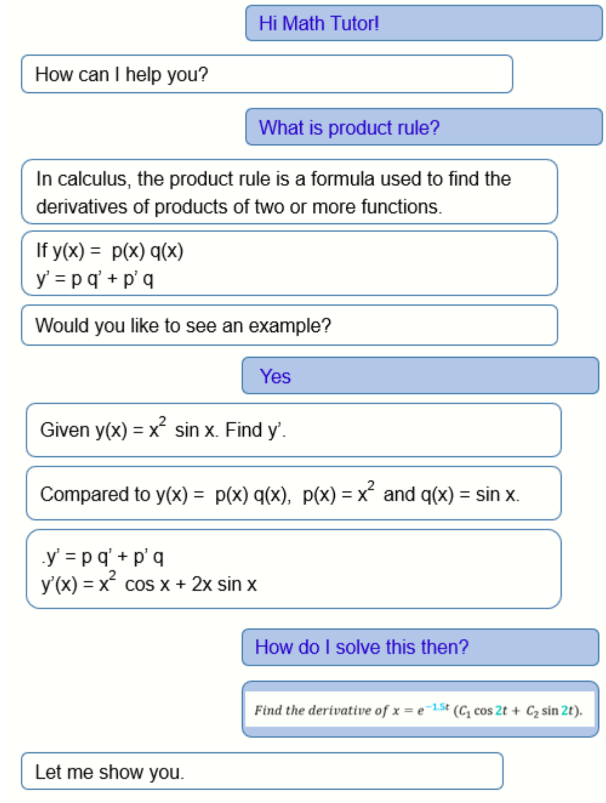


Figure 1 VLA Interface

Methods and Pedagogy

We experimented with the Virtual Learning Assistant (VLA) with a second-year Engineering Mathematics module. This module consists of both face-to-face and online learning components. 50% of the delivery is via synchronous and asynchronous online learning.

Participants

The study on improving instructor immediacy to enhance the learning outcomes was conducted on learners from two diplomas: Diploma in Electronic & Computer Engineering (DECE) and Diploma in Biomedical Engineering (DBME). A total of 82 candidates participated in the study.

Method

The intervention lasted for ten instructional weeks on two topics. We divided the learners into two groups: the experimental and the control group. The experimental group could access the VLA, and the control group used messenger and discussion forum for assistance in learning. At the end of the first topic, all the learners took a topical test to assess their competency level on the first topic. A survey was conducted on the experimental group to gather the learners' perceptions of their learning experience using VLA.

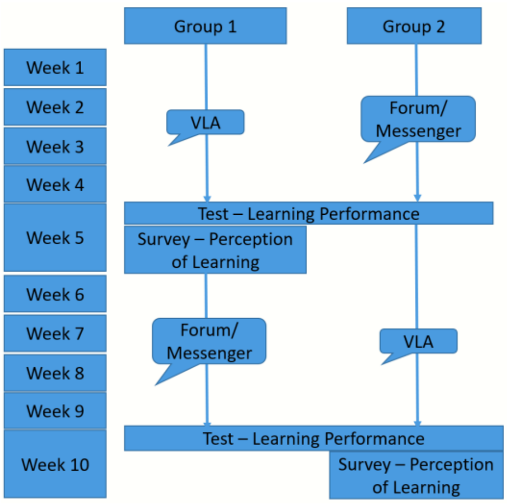


Figure 2 Study Procedure

We introduced a flip flop rotation between the control and the experimental group using a second topic to ensure that both groups benefit from the intervention. The order of which groups undertake which topic will be random to minimise order effects.

Table 1 Flip Flop Rotation Design

	Topic 1		Topic 2	
Group 1	Experimental group: Virtual Learning Support	Test & Survey	Control group: Conventional Methods	Test
Group 2	Control group: Conventional Methods	Test	Experimental group: Virtual Learning Support	Test & Survey

Measures

There were two sets of quantitative data collected. The first set of data was based on the topical test scores while the second set of data was a survey conducted on the experimental group to gather the learners' perceptions of VLA. We used a five-point scale questionnaire to gather information on their learning experiences, motivation level, and cognitive engagement after being exposed to VLA. We also asked the learners their thoughts on what benefited them the most while using the conversational bot.

Results and Discussion

For topic 1, the passing rate in the experimental group is 17% (DECE) and 9% (DBME) higher. After introducing the flip-flop rotation between the control and the experimental group on a second topic, the results were consistent with those of topic 1. For topic 2, the passing rate is 6% (DECE) and 4% (DBME) higher in the experimental group. The number of learners who scored grade B and above is also higher in the experimental group (see Figure 3). This shows that the learning assistance provided by the AI conversational bot leads to more promising results for learners.

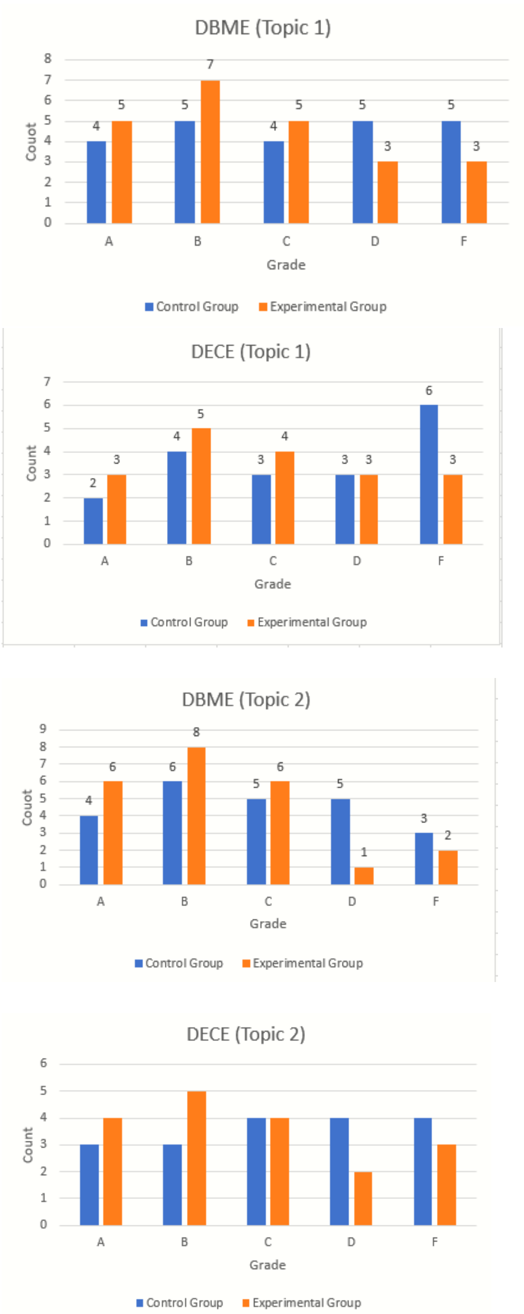


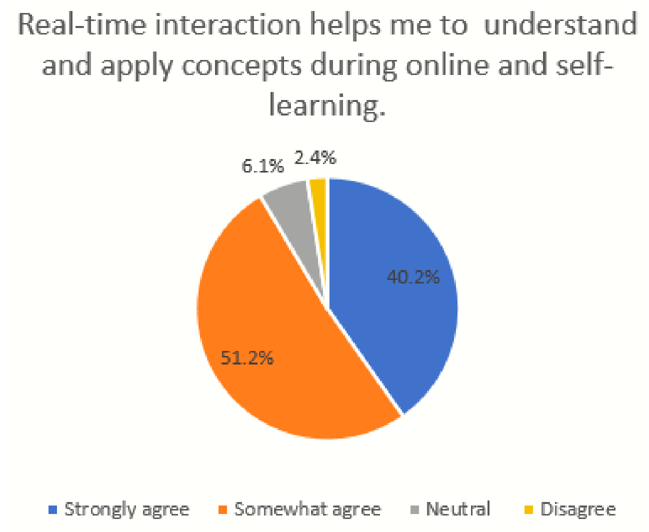
Figure 3 Test Performance (AI conversational bot assisted vs. conventional methods)

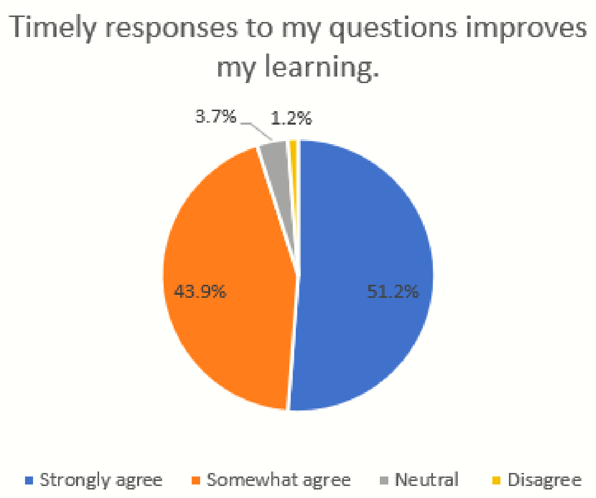
A t-test was applied to explore if there was any significant difference between the performance for learners who used VLA over those who used the conventional approaches such as discussion forums and messenger as learning assistance. For topic 1, DBME t-value was 1.81 which gave a p-value of 0.039; DECE t-value was 1.97 which gave a p-value of 0.028. For topic 2, DBME t-value was 2.19 which gave a p-value of 0.017; DECE t-value was 1.92 which gave a p-value of 0.031. A p-value of less than 0.05 is customarily deemed as significant. Therefore, the results demonstrate an overall significant difference between the performance of learners who used VLA over those who used the conventional approaches. The outcomes are consistent for both topics and are expected to benefit other cohorts of learners.

Table 2 Data analysis (T-test)

	Test	Group	No of Students	Mean	Pooled Std Dev	t-value	p-value
DBME	Test 1	Experimental	23	6.65	2.36	1.81	0.039
		Control	23	5.39			
	Test 2	Experimental	23	7.00	1.96	2.19	0.017
		Control	23	5.74			
DECE	Test 1	Experimental	18	6.33	2.20	1.97	0.028
		Control	18	4.89			
	Test 2	Experimental	18	6.61	2.25	1.92	0.031
		Control	18	5.17			

The survey reflects positive results on the learning experience. The conversational bot helped the learners grasp the concepts and learn more confidently during online learning and self-learning. The learners received timely assistance to firm up ambiguities and build their confidence. As a result, they were motivated to keep on their learning journey. Based on a question-and-answer design, the conversational bot engaged the learners through interactive communications to compensate for the lack of instructor immediacy during online learning and self-learning. The bot made learning more engaging and effective. The ease of use of the bot also improved the learners' learning experience.





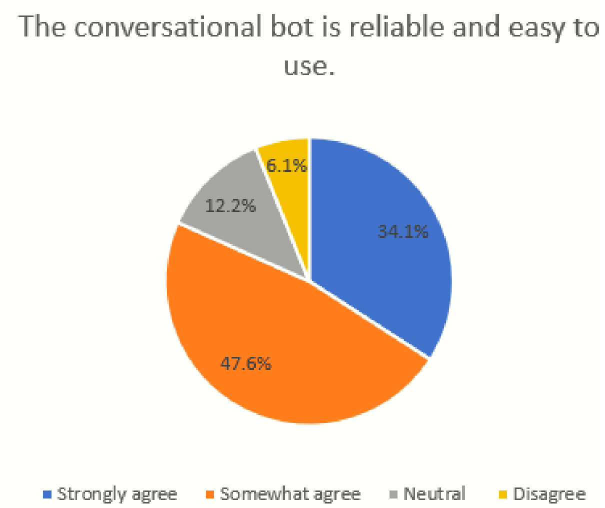


Figure 4 Survey results

The quotes below exemplify the learners' responses on what benefited them the most while using the conversational bot:

"It is easy to use. I can get the answer quickly."

"When I get stuck on stuff, I can ask the bot and get an immediate reply."

"I always have to wait for the teacher to respond when I ask questions in the forum. Now there is no delay. It saves a lot of time."

"I get the information that I need and filter out unnecessary information. It is faster than finding the information from the notes or textbooks."

"It's easier to learn when asking and getting an answer than just reading from the notes. I get tired easily when reading the notes."

Challenges

It is impossible to predicate all potential interaction scenarios. There will be occasions when the conversational bot cannot answer certain questions asked by the learners. The solution is to redirect the questions to the staff via email. The teaching and the support staff will then update the responses in the bot. Consequently, the system will gain greater autonomy and be perceived to be more interactive with a richer database.

Conclusions

The study shows that enhancing instructor immediacy and interaction using an AI conversation bot improves the performance, motivation, cognitive engagement, and learning experiences. Both statistical improvements in the scores and the survey results suggest that the conversational bot is more learner-friendly than the conventional approaches. The conversation bot is well-received by the learners. It can support a large group of learners simultaneously round the clock. Although this paper is primarily based on education experiences made within a mathematic module, this strategy could be generalised to most education courses.

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INTEGRATING SELF-DIRECTED LEARNING INTO CURRICULUM: CONTINUAL IMPROVEMENT USING CDIO FRAMEWORK

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Abstract

The aim of this paper is to share how the CDIO Framework can be used to drive continual improvement in one's program (diploma in Singapore Polytechnic's context). The CDIO Initiative is an innovative educational framework for producing the next generation of engineers through an education stressing engineering fundamentals set in the context of Conceiving, Designing, Implementing and Operating real-world systems and products. Throughout the world, CDIO Initiative collaborators have used CDIO as the framework for their curricular planning and outcome-based assessment. This paper will share a case study of how a diploma used the CDIO Framework to integrate self-directed learning (SDL) in its 3-year curriculum to better prepare students for the future world landscape where being competent means being able to acquire diverse knowledge from different fields to solve problems. The intention of the integration is to progressively prepare students from one who may lack self-confidence in his/her own capability to one that is capable to learning on his/her own and able to use self-directed learning skills in various workplace context, both simulated and real-world. The paper will provide the background of why SDL was integrated, and the approach taken where students were first exposed to the notion of SDL in Year 1 Semester 1 by getting them to look up resources curated for their needs. The explicit teaching of SDL then took place in Year 1 Semester 2 and were infused throughout 15 weeks of lessons in a skill-based module. Students will then continue to apply SDL through the rest of the years of study. The paper also provides clarifications on how relevant CDIO Standards were used to guide the design of various learning experiences for students to progressively develop the competency over their duration of study in the diploma. Work done for the past 4 years and how CDIO is used to drive the continual improvement process undertaken will be described.

Keywords: *Continual Improvement, CDIO, Self-Directed Learning, Program Evaluation*

Introduction

The CDIO Initiative is an innovative educational framework for producing the next generation of engineers. This framework provides students with an education that focusing on engineering fundamentals set in the context of Conceiving, Designing, Implementing and Operating (hence the acronym CDIO) real-world systems and products. CDIO collaborators worldwide have adopted CDIO as the framework for their curricular planning and outcome-based assessment (www.cdio.org). Two key elements of the CDIO Framework are the CDIO Syllabus and the 12 CDIO Core Standards. The Framework is also supported by several optional standards.

The Diploma in Chemical Engineering (DCHE) from Singapore Polytechnic (SP) has been using the CDIO Framework to guide its curriculum redesign since 2007. Over the years, various skills and attitudes have been integrated into the DCHE curriculum with guidance from the CDIO Syllabus and Standards. These include teamwork and communication, critical thinking, global mindset, ethical reasoning, career awareness, and more recently in Semester 2 of Academic Year 2018/2019, self-directed learning (SDL).

This paper explains how the CDIO Standards are used to help the teaching team to continually improve the teaching of SDL competency to students over the last 4 years. Details of the efforts will not be covered here, and readers are referred to papers presented at past International CDIO Conferences (Wong & Cheah, 2022; Wong, Chua & Cheah, 2021; Cheah, 2020; Cheah, Wong & Yang, 2019).

CDIO and Continual Improvement

The 12 CDIO Core Standards are shown in Table 1. Descriptors and rationale for each standard is available at www.cdio.org. The main standard referenced in this paper is Standard 12 Program Evaluation, which is useful in guiding the curriculum review process with the aim of achieving continual improvement. The descriptor for Standard 12 states that:

Program evaluation is a judgment of the overall value of a program based on evidence of a program's progress toward attaining its goals. A CDIO program should be

evaluated relative to these 12 CDIO Standards and any optional standards that it has adopted. Evidence of overall program value can be collected with course evaluations, instructor reflections, entry and exit interviews, reports of external reviewers, and follow-up studies with graduates and employers. The evidence should be regularly reported back to instructors, students, program administrators, alumni, and other key stakeholders. This feedback forms the basis of decisions about the program and its plans for continuous improvement.

Table 1. The 12 CDIO Core Standards

CDIO Standard 1	The Context
Adoption of the principle that sustainable product, process, system, and service lifecycle development and deployment – Conceiving, Designing, Implementing and Operating – are the context for engineering education	
CDIO Standard 2	Learning Outcomes
Specific, detailed learning outcomes for personal and interpersonal skills, and product, process, system, and service building skills, as well as disciplinary knowledge, consistent with program goals and validated by program stakeholders	
CDIO Standard 3	Integrated Curriculum
A curriculum designed with mutually supporting disciplinary courses, with an explicit plan to integrate personal and interpersonal skills, and product, process, system, and service building skills.	
CDIO Standard 4	Introduction to Engineering
An introductory course that provides the framework for engineering practice in product, process, system, and service building, and introduces essential personal and interpersonal skills and the rationale of sustainability in the context of engineering.	
CDIO Standard 5	Design-Implement Experiences
A curriculum that includes two or more design-implement experiences, including one at a basic level and one at an advanced level.	
CDIO Standard 6	Engineering Learning Workspaces
A physical learning environment that includes engineering workspaces and laboratories that support and encourage hands-on learning of product, process, system, and service building, disciplinary knowledge, and social learning, combined with a digital learning environment that includes on-line tools and spaces that support and enhance the quality of teaching and student learning.	
CDIO Standard 7	Integrated Learning Experiences
Integrated learning experiences that lead to the acquisition of disciplinary knowledge, as well as personal and interpersonal skills, and product, process, system, and service building skills.	
CDIO Standard 8	Active Learning
Teaching and learning based on active and experiential learning methods.	
CDIO Standard 9	Enhancement of Faculty Competence
Actions that enhance faculty competence in personal and interpersonal skills, product, process, system, and service building skills, as well as disciplinary fundamentals.	
CDIO Standard 10	Enhancement of Faculty Teaching Competence
Actions that enhance faculty competence in providing integrated learning experiences, in using active and experiential learning methods, and in assessing student learning.	
CDIO Standard 11	Learning Assessment
Assessment of student learning in personal and interpersonal skills, and product, process, system, and service building skills, as well as in disciplinary knowledge.	
CDIO Standard 12	Program Evaluation
A system that evaluates programs against these twelve standards and any optional standards adopted, and provides feedback to students, faculty, and other stakeholders for the purposes of continuous improvement.	

Why Integrate Self-Directed Learning?

Self-directed learning is defined by Knowles (1975) as “a process in which individuals take the initiative, with or without the help of others, to diagnose their learning needs, formulate learning goals, identify resources for learning, select and implement learning strategies, and evaluate learning outcomes”. More recently, SDL has been identified as the key approach for becoming a lifelong learner (Candy, 1991; Alexander, Kernohan. & McCullagh, 2004; Tunney & Bell, 2011). This is analogous to the meta-analytic review done by Boyer et al (2014) on SDL research that spanned over 30 years, five countries, and across multiple academic disciplines, which provided a strong case for using SDL to promote lifelong learning skills in students.

The importance of lifelong learning, and hence the impetus to integrate SDL into our curriculum arose from our use of CDIO to actively scan the changing external environment on issues that can impact teaching and learning, such as the ‘arrival’ of Industry 4.0. It was given further impetus with the launch of the SkillsFuture Initiative introduced by the Singapore Government in 2015 (https://www.skillsfuture.gov.sg/) where fostering a “culture that supports and celebrates lifelong learning” is one of the four key thrusts. The other three are: (2) Help individuals make well-informed choices in education, training and careers, (3) Develop an integrated high-quality system of education and training that responds to constantly evolving needs, and (4) Promote employer recognition and career development based on skills and mastery. This initiative has far-reaching impact on the educational sector, in particular the polytechnics as they aim to prepare graduates for the workforce.

In SP, all diplomas were reviewed to ensure alignment to the requirements of the skills framework(s) for the key stakeholders in the respective industry sector(s) the diploma is serving. To meet the need for lifelong learning, all diplomas are also required to integrate SDL into its curriculum. The Department of Educational Development (EDU) developed a generic model for SDL, as shown in Figure 1 for use by all diplomas. The SDL highlighted 2 key elements: mindset (growth mindset and intrinsic motivation) and skillset (comprising of plan, manage, review, evaluate and extend learning, governed by metacognition). Each

diploma can then further customise the generic SDL model to fit its own respective contexts.

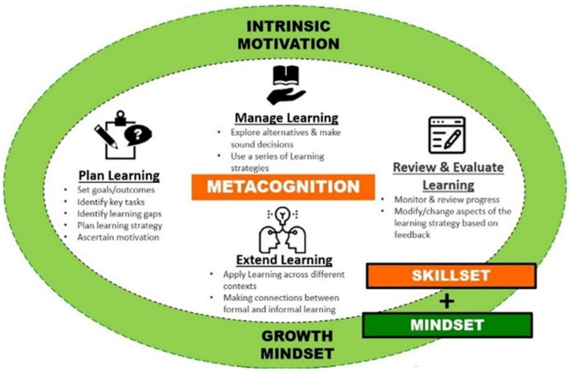

Figure 1. The SP SDL Model

The remainder of this paper illustrates how the CDIO Syllabus and relevant Standards are being used to guide the integration of SDL into DCHE curriculum to the develop SDL competency in our students, and to continually improve the teaching and learning effort.

Importance of SDL in Chemical Engineering

DCHE Course Management Team (CMT) conducts environmental scanning on a regular basis to detect changes in the external operating environment that can affect the teaching of chemical engineering. With the advent of Industry 4.0, we recognised that with the adoption of Industrial Internet of Things (IIoT) technologies, the future job role and nature of tasks that our graduates may perform as process technicians will change (for details of this analysis, see Cheah & Yang, 2018). There will be new competencies that will need to be developed, and existing competencies such as critical thinking that will need to be enhanced. For example, being able to think critically to discern good from bad data is important in light of massive process plant data captured by smart sensors throughout a chemical plant. The ability to understand issues from different perspectives have gained importance as one work with people of other disciplines, often remotely via online platform, a point made apparent from the Covid-19 pandemic. New competencies such as virtual collaboration, teamworking and communicating effectively thus demand new ways of training our students who are accustomed to face-to-face instructions. With limited curriculum hours – which remained fixed for the 3 years of diploma study – but always faced increasing pressure to make room for other non-engineering content meant that technical coverage must be reduced yet remain sufficient for students to apply when in the workplace. SDL therefore becomes ever-more important as we leave out from the curriculum knowledge that students can learn on their own.

DCHE Course Structure to Develop SDL

We recognise that SDL is a high-order competency that needs to be built up gradually, and hence a phased approach was adopted, using our spiral curriculum course structure (Figure 2). Note that Figure 2 shows only the modules relevant to the development of SDL designed based on CDIO Standard 3 Integrated Curriculum. It is worth bearing in mind that the same approach can be used for the integration and progressive development of *any* desired competency.

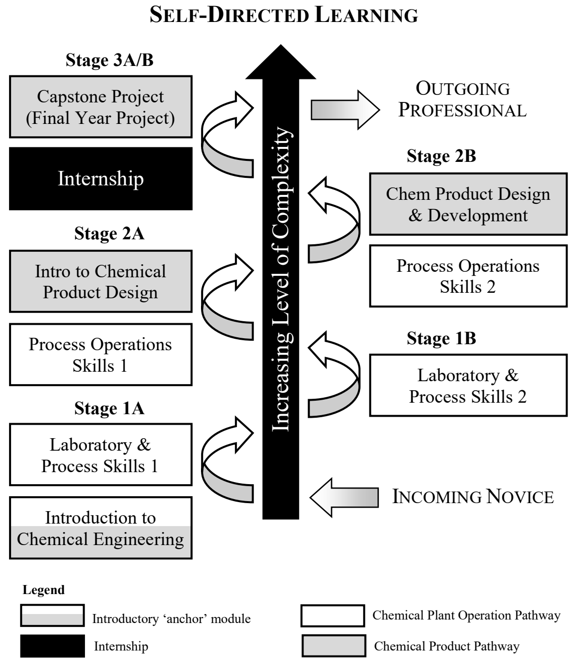

Figure 2. The DCHE Spiral Curriculum

The DCHE spiral curriculum starts with the module *Introduction to Chemical Engineering"* in Stage 1A (Figure 2). This is the 'anchor" module as suggested in CDIO Standard 4. One of the key features of this standard is to introduce students to the profession. This module will then be the "springboard" to move into learning the rest of the modules in the diploma which centered around 2 pathways to prepare students for the chemical industry. One pathway is via a "more standard" approach in chemical plant operation, where graduates either work in chemical laboratories or process plants (Figure 2). In this pathway, skills in laboratory analytical and/or investigative work as chemical plant process operations work are acquired over 4 semesters. The other pathway is the chemical product pathway, where skills in conceiving, designing, implementing and operating a product, process, system or service using chemical engineering principles are developed over 3 semesters (Figure 2), cumulating with the final year capstone project. In addition, students are also expected to apply SDL skills during their internship.

Right from the beginning students are already exposed to the notion of SDL, although often not explicitly mentioned as such. This is done by getting students to read up factual information needed for their work in various modules. Much of the factual

information were previously taught to students in lectures, but now converted as online resources for one's self-learning. Students are then guided in the assignments to make use of these online resources for the work that they need to complete. This serves to sensitise them to the need to look up information that they require.

The integration of SDL into the DCHE curriculum leverage of the 2 pathways mentioned earlier (Figure 2), with explicit teaching of SDL taking place in the module *Laboratory & Process Skills 2* in Stage 1B. This module continues the preparation of students for laboratory investigative work using inquiry-based learning that started with *Laboratory & Process Skills 1* in Stage 1A. It then transitions into process operation skills to prepare students for work in chemical processing plants, using scenario-based learning. Teaching of SDL is carried out throughout the entire module using teaching modelling and guided questions (see the next section on DCHE Approach to Integrate SDL using CDIO).

With the spiral curriculum structure, when students progressed to Year 2, they will continue to hone their SDL competency in the chemical plant operation pathway, via more complex plant operations in module such as *Process Operations Skills 1* in Stage 2A with more scenario-based learning. They will also transfer the laboratory investigative skills to the chemical product design pathway that starts with the module *Introduction to Chemical Product Design* using project-based learning, also in Stage 2A. For their internship, students are expected to apply SDL skills in the workplace they are assigned to, the job scope can be wide-ranging depending on the nature of the company business, students (as interns) can be working in the laboratory or manufacturing facility involving in different tasks such as quality assurance and control, plant operation, work flow improvement, etc.

DCHE Approach to Integrate SDL using CDIO

The rest of this paper presents the work done and continual improvement made to the Stage 1B module *Laboratory & Process Skills 2* which was designed using the CDIO Framework led by the first author, and where SDL was explicitly taught.

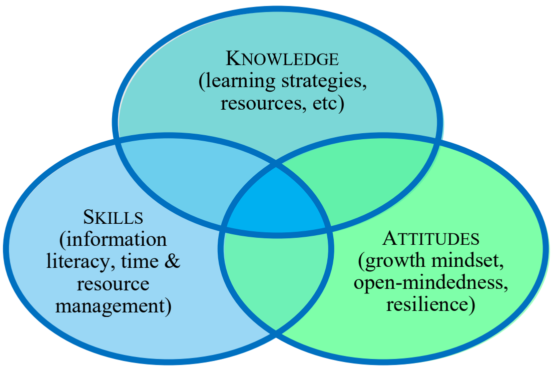

Figure 3. Elements of SDL Competency

In the DCHE approach, we also recognise the importance of leveraging on other skills needed to support SDL, such as information literacy, resilience, etc (Figure 3) and as such highlighted them during the explicit teaching of SDL.

In addition, we also introduced an 'operational' model of SDL as shown in Figure 4, which we used to

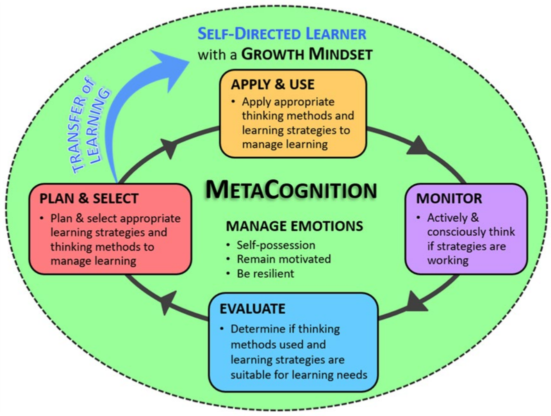

Figure 4. The DCHE SDL 'Operational' Model

guide students along. Several features were made explicit in this model: the iterative nature that one goes through identifying one's learning need(s), writing learning goal(s), formulating learning strategies, monitoring and evaluating the learning process, and appraising the learning outcome(s) and assessing one's progress towards attaining one's state learning goal(s). The need to recognise and manage one's emotion in the learning process, and the ability to transfer one's SDL competency initially develop to other settings are also made explicit.

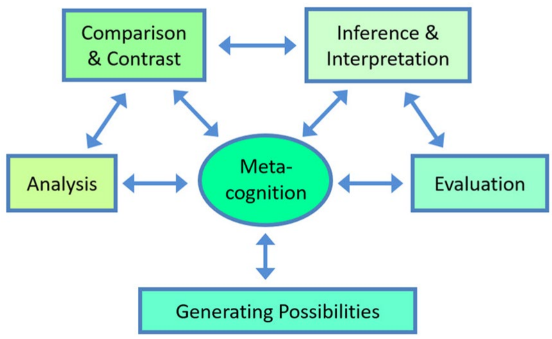

Figure 5. Sale's Model of Thinking

Lastly, to help students deal with the thinking skills behind the key steps in the learning process, and better appreciate the importance of metacognition, we also explicitly teach them various thinking heuristics, based on Sale's Model of Thinking shown in Figure 5 (Sale, 2015).

With all these 'ingredients' in place, we proceeded to use the rest of the CDIO Standards to guide the module redesign effort to integrate SDL. We started with CDIO Standard 1 (The Context), which emphasised the need to consider learning settings that mimic real-world workplace requirements so that learning will be meaningful for students. The learning outcomes (CDIO Standard 2) is written using Bloom's taxonomy, taking reference from the CDIO Syllabus, and matched to the

context in which SDL is introduced. We conducted a briefing during the first week, and 2 workshops using Active Learning methods (CDIO Standard 8) to explicitly teach our students the DCHE SDL Model and Sale's Model of Thinking.

Learning tasks for the module – comprising 10 weekly activities each lasting 4 hours, were designed using CDIO Standard 7 Integrated Learning Experiences, so that students can learn the domain knowledge taught in other core chemical engineering modules in Stage 1B such as *Fluid Flow & Equipment*, and *Heat Transfer & Equipment* as part of horizontal integration in the spiral curriculum as well as growth mindset, communication and teamwork covered earlier in Stage 1A. Based on the desired learning outcomes, all the learning tasks were designed to mimic or simulate real-world scenarios in the context of chemical engineering, so as to provide students with understanding of the job roles and tasks of chemical engineering graduates in various workplace settings, as well as situations whereby one needs to use SDL competency to complete a task at hand. Attainment of desired learning outcomes were achieved via the use of proper scaffoldings to support formative assessment in non-graded activities, and submissions of various reports on work done and reflection journal for summative assessment (CDIO Standard 11 Learning Assessments). There are also 2 debrief sessions – one mid-semester, and another at end-of-semester. The learning tasks were also carefully sequenced to provide a transition from laboratory skills to process operation skills. Especially for process operation skills, the sequencing is important to set students up to use the SDL competency acquired in earlier sessions in later sessions, which involved working in various small-scale pilot plants.

Findings in Brief

Our spiral curriculum with SDL integrated was first rolled out in Academic Year 2018/2019 (AY18/19). Various surveys were done over the years on students' learning experiences with the SDL-infused activities. One major survey was longitudinal in nature, where we followed the cohort of students who entered the polytechnic in AY18/19 from Stage 1A all the way until they completed their final year (capstone) project and internship in Year 3. The first author also partnered with researchers from the Lee Kuan Yew Centre for Innovative Cities (LKYCIC) from the Singapore University of Technology & Design (SUTD) in another project involving volunteers from the same cohort of students, and he leveraged on this partnership to have his LKYCIC partners conduct independent, separate studies on the importance of SDL as perceived by students (Mustafa, et al, 2022).

Suffice to say that overall, majority of students from various cohorts reported that the learning tasks were useful, and results from the LKYCIC Focus Group Discussions also reaffirmed this point. Details of the work done over the years had been reported elsewhere (Wong & Cheah, 2022; Wong, Chua & Cheah, 2021; Cheah, 2020; Cheah, Wong & Yang, 2019). There are of course several areas for improvements as mentioned by students from the other surveys and recognised by the authors. Some of these improvements have been made and are described in the next section.

Continual Improvement in SDL Integration

In SP, there is a mandatory module review every semester. We use CDIO Standard 12 Program Evaluation to guide the module review process (Cheah, Koh & Ng, 2013). Work done in the module were appraised based on findings from the student surveys and reviewed alongside relevant CDIO Standards, most notably Standard 1 The Context, Standard 2 Learning Outcomes, Standard 3 Integrated Curriculum, Standard 7 Integrated Learning Experiences, and Standard 11 Learning Assessment. We present here the some of the work done to improve the module *Laboratory & Process Skills 2*. These improvements were implemented over the years:

- Make connections to previous semester (i.e. Stage 1A) on growth mindset as well as intrinsic motivation. Growth mindset was introduced into the curriculum via a new stakeholder module on ECG (*Education and Career Guidance*, compulsory for all students) that is an institution-wide response to the SkillsFuture Initiative. We also tweaked learning activities in *Laboratory & Process Skills 1* to orientate towards enhancing students' self-efficacy and hence, intrinsic motivation.
- Provide guided questions tailored to specific learning tasks in various activities in *Laboratory & Process Skills 2*, similar to that suggested by Robinson (2020). This was done in response to our findings that students in general faced difficulties in applying the generic questions on SDL that we provided to specific experiments they needed to do.
- Provide URL links to the guided questions in addition to putting them in appendices of laboratory manuals, as a way of offering different ways that they can access the information. In this manner, we also reduce the cognitive loads of students as they can now click through each step of the SDL process to access the guidance questions.
- Design a new learning task that integrates the need to exercise SDL competency in laboratory setting. This new learning task replaced a learning task that was very much 'standalone' in terms of content covered. The new learning task also allows natural transition to process operation skills, thus helping students to form connection between laboratory skills and process operation skills.
- Provide opportunity to apply SDL competency developed in a laboratory session in another follow-up session (within the same learning context with changes in the analysis that students need to perform) using a workbook approach.
- Conversion of an in-class lesson on reading piping and instrumentation diagram (P&ID) symbols and preparation of P&ID Lead Sheet into e-learning

format. This will enable learning can be continued in the event of campus closure, and also allowing students to learn at their own pace (by the given assignment submission deadline), again using a workbook approach. P&ID is the blueprint for a chemical plant with items within represented using various symbols. The lead sheet is like a picture dictionary that explains what the symbol represents in the chemical plant. A chemical engineer or process technician use a P&ID to walk around and understand the plant.

- Provide students with sample reports from earlier cohorts on what constitute good submissions of Reflection Journal, and mistakes to avoid in the preparation of P&ID Lead Sheet.
- Development of a limited functionality digital twin of a pilot plant, to allow students opportunity to practice line-tracing at home in event of campus closure. Scaffolds were provided in the 'campus closure' version so that students can again learn the topic at his/her own pace (by the given assignment submission deadline).
- Development of virtual learning environment in the form of Interactive Video that help students to continue applying SDL Competency in event of campus closure.
- And in the most recent semester, we also created a working template that takes students through the step-by-step process of SDL as per Figure 4.
- Lastly, we also started a new initiative to explicitly make students collaborate in the virtual space in their preparation of the P&ID Lead Sheet

Some for the improvements mentioned above represent efforts that are not only geared towards improving students' development of SDL competency, but also to ensure that learning can continue uninterrupted to the extent possible during a pandemic when campus closure is unavoidable.

Conclusion

This paper shared how we used the CDIO Framework to guide in the redesign on a module to integrate SDL into a 3-year curriculum. As we journey along in the effort of developing self-directed learners, we remain committed to make references to the CDIO Framework for guidance, especially in the spirit of continual improvement.

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A CASE STUDY FOR THE PLANNING AND ADOPTION OF PROJECT-BASED LEARNING IN IT CURRICULUM

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Abstract

Project-based Learning (PBL) is an integrated teaching and learning pedagogy that encourages students to self-learn and acquire knowledge and skills by working on real-life problems. The Vocational Training Council (VTC) has adopted the PBL pedagogy in her 3-Year Strategic Plan in 2020-2023. A progressive, institutional-wide adoption has been in place after an extensive pilot study in her member institutions. It is regarded as one of the major learning and teaching strategies for effective delivery of skills-based training across different disciplines. At VTC, PBL is highly student-driven as it allows them to participate and develop inter-disciplinary projects from the very beginning, real-life and authentic as the driving questions are defined primarily by the inputs from industry through close collaboration with industrial partners, and being public as opportunities will be given to students to present their products and deliverables to a public audience. In summary, the council defined her PBL implementation with four essential elements, namely (i) student-driven, (ii) real-life, authentic and inter-disciplinary, (iii) collaborating with industry, and (iv) integrating with the quality assurance system. Following the framework defined, member institutions of VTC are progressively adopting PBL in their own vocational curriculums. This paper will study the strategies and challenges in the successful adoption case of PBL in the IT discipline of the Institution of Vocational Education (IVE) under the VTC. There are 17 different programme curriculums involved in the areas Information and Communication Technologies and Multimedia and Entertainment Technologies. The curriculums are re-designed to unleash the maximum benefits to students and a systematic approach is employed to ensure the pace of adoption across the programmes is aligned and the outcomes are as expected. The adoption planning, strategy, PBL approaches, project path planning and Quality Assurance mechanism used will be presented in the content. Finally, successful project samples, challenges encountered and stakeholders' feedbacks from students, teaching staff and the industry will be reviewed and discussed.

Keywords: *project-based learning, PBL, data science, AI, vocational education, learning pedagogy*

Introduction

In the Vocational Training Council (VTC) 3-Year Strategic Plan for 2020-2023, Project-based Learning (PBL)(PBLWorks, n.d.) is regarded as one of the major strategies of learning and teaching for the delivery of skills-based training across subject disciplines. Through enriching the curriculum, PBL enables students to develop key competencies in Vocational and Professional Education and Training (VPET) in the 21st century. It further characterises the VPET learning and teaching practices, thereby strengthening the position of VPET. A progressive, institutional-wide adoption has been in place in the member institutions of VTC.

As a member of the VTC Group, the Hong Kong Institute of Vocational Education (IVE) is the leading vocational and professional education provider in Hong Kong, committed to nurturing professionals valued by industries. IVE has been evolving in tandem with the economic development of Hong Kong, building a competent and innovative workforce needed in a knowledge economy. The Information Technology Discipline (ITD) in IVE is her arm to deliver high-quality technology education and vocational training in Hong Kong. It currently offers 15 full-time and 2 part-time higher diploma programmes in different technology areas. The adoption of PBL pedagogy into the curriculums will involve over 150 teaching staff and affect over 500 generic and vocational modules. The process is complicated and has to be carefully planned and executed. The focus of this paper is to share the large-scale planning and adoption experience of PBL in ITD/VTC for reference by other education practitioners.

As of AY2021/22, each full-time programme in ITD/IVE has adopted an integrated or standalone PBL project and an industrial collaborative PBL project in its curriculum. The benefits to students' learning can be reflected in the outcomes of these projects. Taking the Higher Diploma of Data Science and Analytics (HDDSA) as an example, research papers written based on students' project works were published in the 14th International Conference on Communication Systems & Networks (COMSNETS) in 2022 and awards were received in

different local and national competitions, including the ICT Award, Pan-River Delta IT Project Competition Award, Hong Kong University Student Innovation and Entrepreneurship Competition and IET's Young Professionals Exhibition & Competition since an industry collaborative ecosystem was established for PBL projects.

The IT Programmes undergoing PBL Adoption

The Information Technology Discipline (ITD) in IVE/VTC currently offers 15 full-time and 2 part-time higher diploma programmes in different technology areas as tabulated in Table 1. The full-time programmes have a duration of 2 years in 5 semesters, with a minimum 90-hour industrial attachment. Their curriculum normally carries 300 to 330 credits, representing 1,125 to 1,228 contact hours or 3,000 to 3,300 notional learning hours. Each programme is consisting of 30 to 35 modules and approximately 500 modules will be involved in this PBL adoption. The goal is to implement the PBL pedagogy into all programme curriculums in 3 years, with an adoption rate of 50% by credit.

Table 1. Programmes being offered by ITD/IVE/VTC as of 2022.

1	HD in Telecommunications and Networking
2	HD in Telecommunications and Networking (E&L)
3	HD in Software Engineering
4	HD in Game Software Development
5	HD in Cloud and Data Centre Administration
6	HD in Cloud and Data Centre Administration (E&L)
7	HD in Data Science and Analytics
8	HD in AI and Mobile Applications Development
9	HD in Cybersecurity
10	HD in AI and Smart Technology
11	HD in Financial Technology
12	HD in Games and Animation (Animation)
13	HD in Games and Animation (Games)
14	HD in Theme Park and Theatre Creative Technology
15	HD in Multimedia, VR and Interactive Technology
16	HD in Information and Communications Technology (PTE)
17	HD in Multimedia and Entertainment Technology (PTE)

Challenges in Planning and Adoption

The adoption of PBL into a single programme curriculum was not difficult but synchronizing the pace of adoption for all programmes in a discipline with the same quality standard was another story. The five key challenges experienced were:

(i) The existing programmes had a fine modular structure and long programme hours. It was difficult to fit in a PBL project in existing modules or introduce a new PBL project module.
(ii) How to ensure the new teaching material and assessments were at the same quality standard across the programmes?
(iii) How to ensure teaching staff were well equipped with the required knowledge for the change?
(iv) The need for a quantitative measure for the PBL adoption level in programmes and to synchronize their pace of adoption.
(v) How to establish a sustainable ecosystem with the industry to provide continuous, updated inputs on real-world, authentic challenges?

The responses to the above challenges will be discussed in the following sections of this paper.

PBL in VTC

Project-based learning (PBL) is a teaching pedagogical approach to motivate students on their learning process by working for an extended period of time to investigate and respond to a complex question, problem, or challenge (PBLWorks, n.d.). As an organization focusing on VPET, VTC has adopted the essential elements of PBL with her own values as shown in the diagram below:

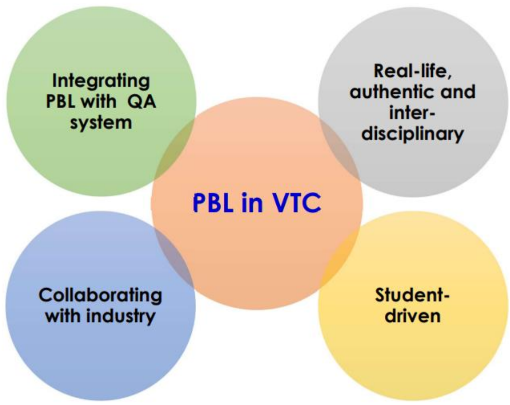


Figure 1. VTC's version of PBL (Source: VTC PBL Handbook v2.1)

The PBL in VTC embraced her core competencies in programme Quality Assurance (QA) and industry collaboration and at the same time ensured the authentic, cross-disciplinary nature of projects driven by students. For quality assurance, most PBL assessments in our case were presented in the form of End-of-module Assessments (EA) or Continuous Assessments (CA) in a module. The validity, reliability and practicality of these assessments were constantly monitored by the existing QA mechanism in VTC. The QA management structure was formed by the teaching staff, programme boards and the senior management. The voice of students, staff, external examiners and other stakeholders will be reflected in the Module Quality Analysis Report (MQAR) prepared every semester and the Programme Quality Analysis Report (PQAR) prepared every academic year. For the purpose of ensuring the authenticity and real-life nature of the PBL projects, the definition of driving questions and the project implementation were often done in collaboration with the industry. Students normally started their industrial attachment after semester 3 in their first-year study. An authentic and

real-life driving question relating to the attachment would be defined for their final year project. Thereafter, students worked with their supervisor and workplace mentor to explore an innovative solution for the challenge.

In the design of the industrial collaborative PBL projects, the concepts proposed by the Buck Institute for Education (PBLWorks, n.d.) is followed. The key elements are illustrated below:

1. Challenging Problem or Question
The project is framed by a meaningful problem to be solved or a question to answer, at the appropriate level of challenge.

2. Sustained Inquiry
Students engage in a rigorous, extended process of posing questions, finding resources, and applying information.

3. Authenticity
The project involves real-life context, tasks and tools, quality standards, or impact, or the project speaks to personal concerns, interests, and issues in the students' lives.

4. Student Voice & Choice
Students make decisions about the project, including how they work and what they create.

5. Reflection
Students and teachers reflect on the learning, the effectiveness of their inquiry and project activities, the quality of student work, and obstacles that arise and strategies for overcoming them.

6. Critique & Revision
Students give, receive, and apply feedback to improve their process and products.

7. Public Product
Students make their project work public by explaining, displaying and/or presenting it to real audiences.

PBL Adoption Planning and Execution

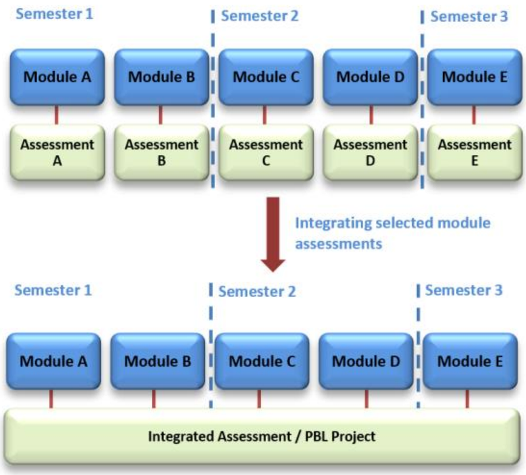
The Adoption process of the PBL in the IT discipline was planned to take 4 years to complete, 1 year for the preparation and 3 years for the implementation. The main activities included the training of staff, revision of programme documents, project planning, teaching material development, etc.. The key activities at different stages and their focuses were summarized in Table 2. In the preparatory year, the trainings were focused on the PBL concepts and backgrounds, training the trainers, curriculum design and pilot case sharing as most teaching staff were unfamiliarised with the PBL pedagogy, while the adoption activities included pilot runs, curriculum revision and the establishment of industrial ecosystem. In the first year of adoption, PBL projects were launched for all programmes in their year-1 curriculum, trainings on teaching material design, assessments design and quality assurance were provided in support of the launch. In the second year of adoption, PBL projects would be launched in all year-2 curriculums, trainings including case review and sharing of good practices would be delivered. In the last year of adoption, a full review could be conducted as the cycle should be completed, the reflections could be used to enhance the materials, delivery and the process.

Table 2. A 3-year PBL Adoption Planning for IT curriculums.

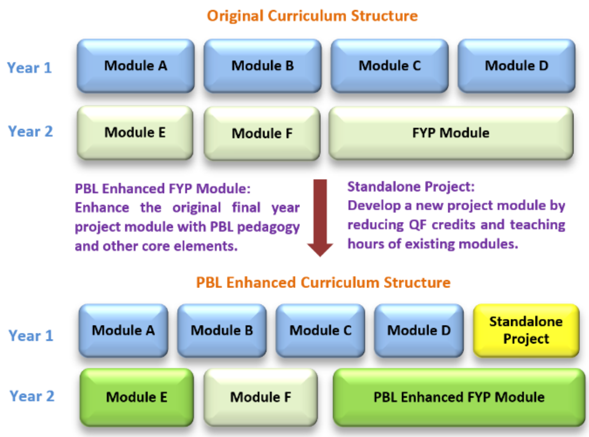
Year	Training	Execution	Programme Adoption Percentage (by Credit)
AY20/21 Preparation	PBL Concepts, Train the trainers, Curriculum Design, Implementation Briefing, Pilot Case Sharing	Pilot Programme, Curriculum Revision, Industrial Ecosystem Setup	N/A
AY21/22 (1st year)	TLP Writing, PBL Assessments, Quality Assurance, Progress Update and Sharing	Yr-1 PBL module teaching material development, and project delivery	30%
AY22/23 (2nd year)	Stage Review Case Sharing, Good Practice and Challenges	Yr-2 PBL module teaching material development, and project delivery	40%
AY23/24 (3rd year)	Full Cycle Review	Review and Enhancement	50%

In the adoption process, challenges described in previous subsections were addressed. The first challenge arisen from the fine modular programme structure and long programme hours. The granularity made it difficult to fit in a PBL project inside any existing modules and the long hours made it difficult to introduce a new PBL project module for students to investigate a complex question over an extended period. For flexibility, three adoption approaches were proposed and implemented. Programme teams were allowed to select the best approach in consideration of their own operational needs. The first approach, PBL Integrated Project, was depicted in (b)

Figure 2(a), it integrated assessments from a few selected modules into a single project. Each of the assessments would contribute to one or more key PBL elements and formed a complete solution to the driving question as a whole. The advantages for this approach were (i) minimal changes to original programme structure, (ii) little additional workload to students and (iii) enhanced flexibility on project duration. The main concerns were the project flow would be difficult to control.



(a)



(b)

Figure 2(a) Approach 1 – PBL Integrated Project and (b) Approach 2 – Standalone Project; Approach 3 – Enhanced FYP Module.

In Figure 2(b), PBL could also be adopted by the development of a new standalone project module by reducing the credits and teaching hours of other modules. This approach provided a better control over the project flow at the expense of (i) a reduction of teaching hours on other modules and (ii) a potential increase of students' workload and (iii) a programme structure revision. As all existing HD programmes in ITD had a Final Year Project (FYP) module in their curriculum, they would be enhanced by adopting PBL pedagogy, inter-disciplinary and industry collaboration elements.

To facilitate PBL adoption at the same pace, the credits of modules that adopted PBL would be accumulated and calculated across all programmes. The progress would be timely updated and synchronized. To address the challenge on quality assurance, various standardized templates were created and shared among teaching staff. For example, the project brief template as demonstrated in Figure 3.

Figure 3. Sample project brief.

The project brief contained all necessary information including the driving question, background, project path and milestones, assessment rubrics, etc. for reference by both students and teachers. The module assessments at different project stages were clearly shown as in Table 3. The Module Intended Learning Outcome (MILO) mapped to the PBL project and their intended deliverables were also included for quality review.

Table 3. The module assessment mapping for different project stages.

Integrated Assessment	Assessment Components	Module
Initial Study and Ideation	Project Plan	ITP3109 (EA)
	Dataset and Data Models	ITP3109 (EA)
	Data Design	ITP4903 (CA)
	Project Idea Video	LAN3100 (CA)
Product Prototyping and Evaluation	Draft Prototype and Peer Review	ITP4863 (CA)
	Performance Evaluation Report	ITP4863 (CA)
	Data Governance Policy Document	ITE4103 (CA)
Product Presentation and Demonstration	Final Prototype and Report	ITP4869 (CA)
	Project Presentation and Demo	ITP4869 (CA)

Table 4. The Module Intended Learning Outcome (MILO) mapping to the PBL project.

Module Code	Name of Module	Mapping of Modules' Intended Learning Outcomes (MILOs)					Deliverable(s) from each module for the Project
		MILO 1	MILO 2	MILO 3	MILO 4	MILO 5	
ITE3109 (S1)	Data Science and Big Data Fundamentals				✓		Project Plan Dataset and Data Models
ITP4863 (S2)	Business Statistical Modeling	✓	✓	✓	✓	✓	Performance evaluation report
ITE4103 (S3)	IT Professionalism		✓				Data policy for the data collected in the Manpower Survey.
ITP4903 (S1)	Database Principles	✓	✓				Data Design - Entity Relationship Diagram for the data collected.
ITP4869 (S3)	Analysis with Programming Tools		✓	✓	✓		The analytic solution Demonstration and peer review of the solution.
LAN3100 (S1)	English & Communication (Workplace Interaction)	✓	✓				Participate effectively in discussions/meetings with the team on topics/issues; Present their idea to clients so as to demonstrate their communication skills to express compliments, persuasion and emotion in the form of a video.

Sustainable Ecosystem for Industrial Collaborative Projects

A key step in successful PBL implementations is the driving question should represent a real-world, authentic challenge. To secure updated and continuous inputs for the driving questions. An ecosystem with industrial partners was formed under our Industrial Attachment (Internship) programme. Students will be assigned to partnering organizations as interns for acquiring on-job experience and skills. During the internship, academic supervisor will work with the workplace mentor to define suitable driving questions in related application area. Students will be opted to continue his works as a final year project. The arrangement allows students to apply their skills learnt to solve real-world challenges and at the same time the employers were supplied with new talents. Since the adoption of PBL, a significant number of successful industrial collaborative projects were developed in the discipline. An outstanding student project sample is presented below to demonstrate how PBL standards and VTC's core values integrated.

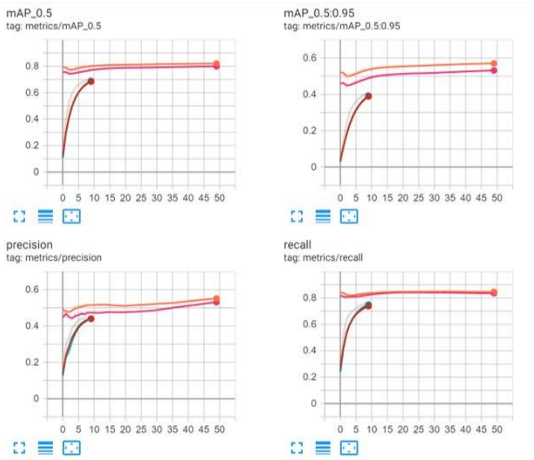
Drone-based Search and Rescue System for Extreme Terrains

The system "*Drone-based Search and Rescue System for Extreme Terrains*" is inspired by the driving questions of "How do we effectively use drones to relieve the manpower and risks for mountain search and rescue in Hong Kong?" co-defined with industrial partners. The students first studied the existing practices in mountain search and rescue and identified the areas for improvements, including the risks encountered by rescue team crews, mission timeliness and effectiveness. Then, students researched for suitable technologies and designed an innovative solution based on IoT (Internet of Things) and AI (Artificial intelligence) vision technologies to facilitate a safer and more efficient search and rescue mission management and execution. With the skills learnt from the programme and their industrial attachment, a system that can control a fleet of drones to search a designated area in the wilderness was developed. The mobile app interface for the rescue team crew was shown in Figure 4 below. A user-friendly interface was provided to control the mission and to locate victim through the proprietary AI vision model trained.

Figure 4. Mobile App interface for rescue team crew.

Throughout the project period, students developed and monitored their own project development plan and reported their progress in timely manner. They analysed, designed, implemented, tested, evaluated and refined the proposed solution corresponding to the driving question. The AI vision model to identify victims was trained and optimized from raw datasets as demonstrated in Figure 5(a). The performance of the candidate AI models was analysed with mAP (mean Average Precision), precision, recall and tuned with hyperparameters including image size, batch size and epoch numbers as shown in Figure 5(b). The best model was selected based on their findings.

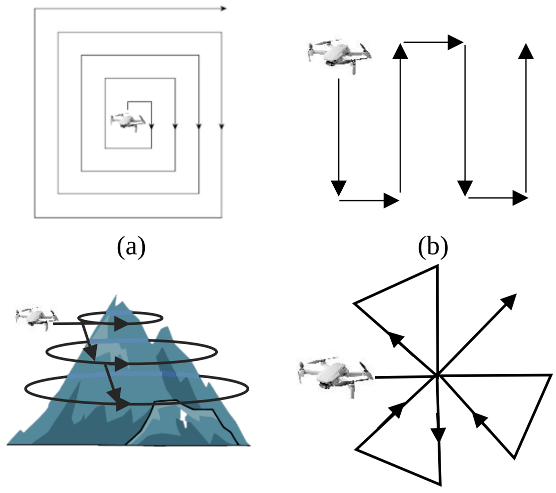
(a) A sample image in the raw dataset.



(b) Performance measures for candidate AI vision models for humanoid object identification.

Figure 5. Sample data and performance of candidate AI vision models.

Another innovative and practical function proposed by the students were the pattern search functions for the drone fleet. Students researched the rescue methods used by aircraft and sea vessels (IAMSAR) and selectively adopted those fit for the problem scenario. They also utilized the "way-point" feature in the API library of the drone to implement different search patterns as shown in Figure 6 for different situations. The targeted area could be searched thoroughly and seamlessly in a short time by the drone fleet.

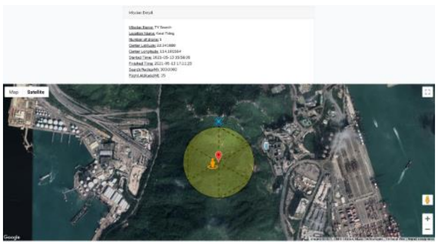


(a) (b)

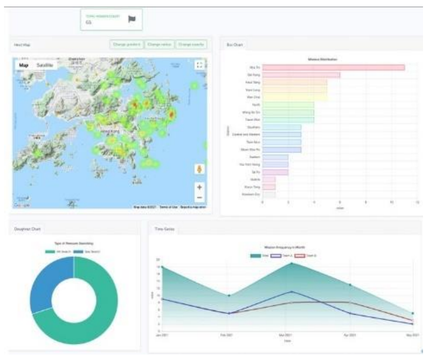
(c) (d)

Figure 6. IAMSAR search patterns (a) Expanding Square (b) Creeping Line (c) Contour and (d) Sector.

With the continuous feedback from stakeholders, the functions of the headquarter web application was enriched and its interface enhanced. As shown in Figure 7, the mission management, reporting and visualization of mission statistics were provided.



(a) Rescue Mission Report



(b) Visualization of mission statistics

Figure 7. Headquarter Web application interface.

The project was publicly presented in various exhibitions and competitions. It was publicized by various medias and received awards including the first prizes for the Pan River Delta University Student Project Competition. Students enjoyed the process and were highly motivated to perfect their work with the encouragement from public recognition.

Figure 8. Product presentation in public

Conclusion

This paper shares the large-scale planning and adoption experience of PBL pedagogy in the IT discipline of IVE/VTC. The implementation details and challenges were discussed. A total of 17 full-time and part-time programmes are committed in the 3-year implementation plan. In the adoption of the PBL pedagogy, the core values of VPET and VTC's quality assurance system, industry collaboration and interdisciplinary concepts are also seamlessly integrated into the curricula. The benefits are well observed from the students' feedbacks and the many successfully project stories since adoption.

Acknowledgements

We gratefully acknowledge the contributions from all programme teams in ITD and the great support from the Centre for Learning and Teaching, Quality Enhancement and Accreditation Office, the project teams of the HD in Data Science and Analytics and all our industrial partners.

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DEVELOPING PROTOTYPE OF A SPEECH CORPUS FOR ASSISTING LANGUAGE LEARNING

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Abstract

A learners' corpus is expected to accelerate language education and learning by allowing us to observe a large amount of linguistic data from a macro perspective and narrow it down to a micro perspective with high accuracy. However, in most cases, many of the existing corpus contain written text data and ones that contain audio data are limited in terms of usability. Even if they do, it is quite possible that they are not collected with intention to conduct prosodic research, and therefore they are not suitable to observe and analyze how the interlanguage change or what learners of different learning experience or different native languages have in common. In this paper, we have developed a prototype of a learners' corpus, "Japanese Learners' Speech Corpus (JALSPEC)," specifically designed for observation and analysis of the prosodic aspects of Japanese language learners. JALSPEC contains both audio and text data of learners of the following native languages; Chinese, Korean, English, Thai, Hindi, Vietnamese, Portuguese, Persian, Russian, Polish, Telugu and Danish. Also, Informants were asked to perform the following tasks which are designed to analyze various prosodic features; Reading aloud task for statistical analysis of micro level prosodic features, self-introduction task, story-telling task for discourse analysis, role-play task for analysis of how they build consensus. Currently, most of the collected data are released with fully capable user interface. However, the user interface that enables us to run a simple analysis online is yet to be implemented. Also, it is necessary to improve overall usability of the corpus.

Keywords: *Second Language Acquisition, Corpus Linguistics, Data-Driven learning, Japanese as a Second Language, Japanese Phonology*

Introduction

A corpus is a database of a large amount of language materials. Among them, the corpus that contains learners' language, not the language produced by the native speaker, is called learners' corpus. This learners' corpus allows us to observe and analyse the "interlanguage," which is a complex language system that learners form in the process of the acquisition of the target language, and thereby, for example, it is possible for us to discover common characteristics about a specific vocabulary, grammatical mistake or error, prosodic features regardless of their native languages, learning experience or their proficiency. In this way, learners' corpus is expected to accelerate language education and learning by allowing us to observe a large amount of linguistic data from a macro perspective and narrow it down to a micro perspective with high accuracy. In addition, in most cases, many of the existing corpus contain written text data and ones that contain audio data are limited in terms of usability. Even if they do, it is quite possible that they are not collected with intention to conduct prosodic research, and therefore they are not suitable to observe and analyse how the interlanguage change or what learners of different learning experience or different native languages have in common. In this paper, we introduce a prototype of a learners' corpus, "Japanese Learners' Speech Corpus (JALSPEC)," specifically designed for observation and analysis of the prosodic aspects of Japanese language learners.

Design of JALSPEC

As mentioned above, JALSPEC is specifically designed for prosodic research with the following features.

Learners' Native Languages and Task Variations

JALSPEC contains both audio and text data of learners of several native languages; Chinese, Korean, English, Thai, Hindi, Vietnamese, Portuguese, Persian, Russian, Polish, Telugu and Danish. Also, Informants were asked to perform the following tasks which are designed to analyse various prosodic features. By doing so, it allows us to analyse the levels of proficiency required to perform each task [Figure 1].

Figure 1. Introduction Page of JALSPEC

Task 1: Reading Aloud Short Sentences

Informants were asked to read aloud several short sentences with at least one target in each sentence that learners tend to mispronounce [Figure 3, 4]. After reading aloud, learners were also asked to report the word(s) they found difficult or did not know. Below is an example of short sentences presented to the informant.

Hiroshima daigaku wo taigaku shimashita.
(I have left Hiroshima University.)

The target in this sentence is a minimal pair voiced and unvoiced consonant, /d/ and /t/. Learners of Chinese native speakers tend to mispronounce those minimal pair consonants as they are not distinguished in Chinese language.

Task 2: Self Introduction

Informants were asked to introduce themselves in two minutes. This task is designed to analyse their monologue and what kind of topics they choose to talk about when they meet someone for the first time [Figure 5].

Task 3: Story Telling

Informants were asked to talk about anything they have done recently, such as movies they have seen or books they have read. Also, informants were informed that there was no requirement about how long they were expected to talk or what kind of topics to talk about. As a result, the length or topics they talked about differ from one informant to another [Figure 6].

Task 4: Role-Play

Informants were paired and presented a pair of following roles, A and B [Figure 7], and C and D [Figure 8]. Below are the instructions written on each role card.

Role A: Person B is your close friend and your classmate. One of your classmates is heading back to his/her country next week. You are throwing a farewell party for him/her. Time and date are yet to be decided. You can bring anything you want to eat. Ask person B to come to the party with you.

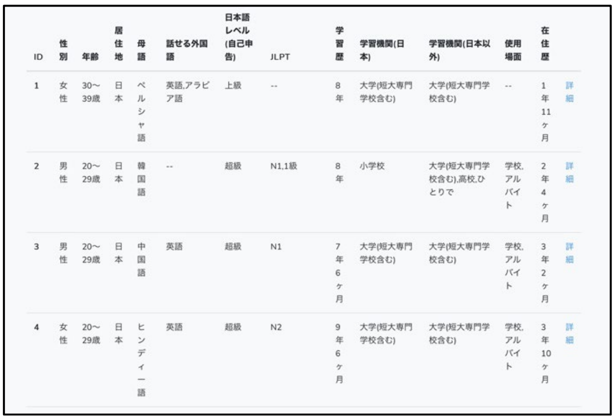
Role B: Person A is your close friend and your classmate. Person A and other classmates are going to throw a farewell party for one of your classmates who is going back to his/her country. Person A asks you to come to the farewell party next week, but you have a part-time job. Decline the offer.

Role C: You work part-time at a convenience store and your shift starts at 6 pm. You are on the way to your workplace, but the traffic is so busy that it seems to be difficult to make it in time for your shift. Call the manager and ask what to do.

Role D: You are a manager at a convenience store. You got a call from one of the part-time employees, who often comes late for his/her shift. Take the call and tell him/her what to do considering his/her situation.

Annotation

For each informant, the following items were tagged; ID, sex, age, current residential area, native language, level of Japanese, learning experience, institution they graduated in/out of Japan where they use Japanese and dwelling history in Japan [Figure 2].



ID	性別	年齢	居住地	母語	話せる外国語	日本語レベル(自己申告)	JLPT	学習歴	学習機関(日本)	学習機関(日本以外)	使用場面	在住歴	
1	女性	30〜39歳	日本	ペルシャ語	英語,アラビア語	上級	--	8年	大学(短大専門学校含む)	大学(短大専門学校含む)	--	1年11ヶ月	詳細
2	男性	20〜29歳	日本	韓国語	--	超級	N1,1級	8年	小学校	大学(短大専門学校含む),高校,ひとりで	学校,アルバイト	2年4ヶ月	詳細
3	男性	20〜29歳	日本	中国語	英語	超級	N1	7年6ヶ月	大学(短大専門学校含む)	大学(短大専門学校含む)	学校,アルバイト	3年2ヶ月	詳細
4	女性	20〜29歳	日本	ヒンディー語	英語	超級	N2	9年6ヶ月	大学(短大専門学校含む)	大学(短大専門学校含む)	学校,アルバイト	3年10ヶ月	詳細

Figure 2. Annotation for Each Informant

Figure 3. Sentence Examples of Task 1

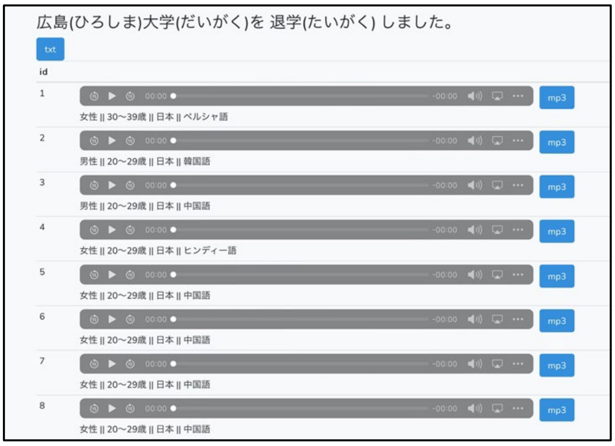


Figure 4. Audio Play Page for one sentence by different informants

Figure 5. Text Data and Audio Play Page of Task 2

Current Situation and Discussion

Currently, most of the collected data are released with fully capable user interface. However, the user interface that enables us to run a simple analysis online is yet to be implemented [Figure 9]. Also, it is necessary to improve overall usability of the corpus.

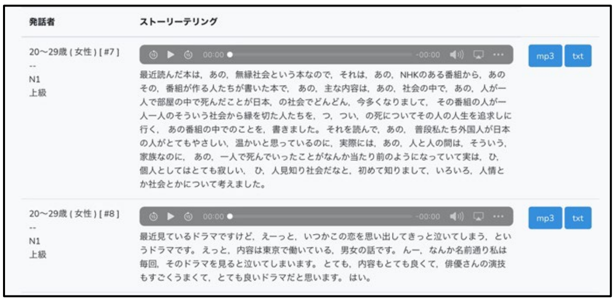


Figure 6. Text Data and Audio Play Page of Task3

Figure 7. Text Data and Audio Play Page of A and B

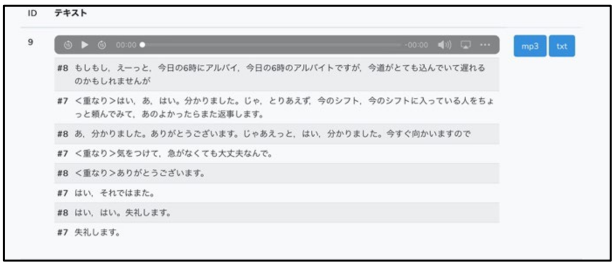


Figure 8. Text Data and Audio Play Page of C and D

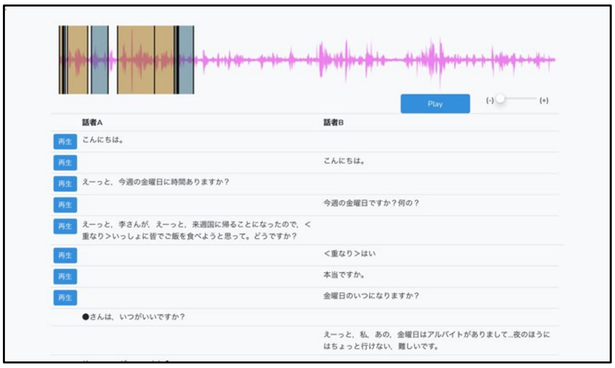


Figure 9. User Interface for Simple Analysis Online

Conclusions

This study aims to accelerate and promote Japanese language education by developing a large-scale multilingual speech corpus that allows us to analyze and observe various factors of prosodic aspects. Also, for the purpose of widely sharing speech data, JALSPEC contains not only speech data of various learners of different linguistic or cultural background, but also speech data gained by four different tasks that require different skills. However, to build a full version of JALSPEC, the user interface that enables us to run a simple analysis online needs to be implemented. Also, it is necessary to improve overall usability of the corpus.

Acknowledgements

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THE IMPROVEMENT OF STUDENTS' COOPERATIVE SKILLS, CREATIVITY, AND THINKING SKILLS THROUGH DESIGN-THINKING-BASED ENGLISH CLASSES LEARNING EXPERIENCE

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Abstract

Starting in 2020, with the support of Singapore Polytechnic (SP), National Institute of Technology, Nagaoka College (NITNC) developed new English courses called "Essential Thinking classes." These English courses provide several chances to enhance engineering major students' skills using a new pedagogy tool of the design-thinking framework. The staff in SP provided valuable ideas to consider for the general course framework, the assessment policy of students' achievement and the procedure for teaching (Ominato et al., 2021). These new courses have been a challenge for our teaching staff as well as for our students in NITNC. The aim of this new course is to develop not only English skills but also cooperative skills and thinking skills throughout its critical thinking, logical thinking, and communicative activities. Furthermore, since it mainly employs processes of ideation in each module, it is highly expected that our students will improve their creativity simultaneously with their thinking skills. In this study, a follow-up questionnaire was conducted to ascertain how conscious NITNC students are of their own improvement in cooperative skills, thinking skills, creativity, and English skills. Participants of this study were 206 first year students taking English IC classes for their essential thinking learning experience and 209 second year students who were taking English IIC, which was their second year of experiencing this course. The total number of participants was 415 students: 340 boys and 75 girls. Four of them were non-Japanese students who are international students from Thailand. In the questionnaire, we also asked the participants to identify one of the most cooperative, creative students and one student who seems to have advanced thinking skills. The students were then asked to explain why they selected these students. Combined with the results of the questionnaire, PROG Test data was analyzed to determine student's beliefs about their skills. The PROG Test is a "program to develop the general abilities, attitudes, and orientation - generic skills - required in society as a university graduate, regardless of their majors or specializations." In this study we will be able to demonstrate what kind of students are believed to be cooperative, creative, and thought to have a high thinking ability.

Keywords: *design thinking, cooperative skills, thinking skills, creativity, EFL, generic skills*

Introduction

Based on the concept Tsuchida et al. (2021) suggested in their Nagaoka CO-CORE Vision of NITNC, we developed new English classes to foster Kosen students' generic skills. Even though "design thinking" process is quite common in engineering education, for us English teachers at the time, the process of design thinking was the latest approach to teach and took some time to understand. We can find plenty of papers which report educational approaches using design thinking process in engineering education. (WON et al., 2018, Cheung et al., 2018, and Shirahama, et al., 2018).

Pedagogy

In NITNC, English communication classes were previously given throughout five years of Kosen. Now, these classes have been replaced with Essential Thinking classes which are provided for the first-year students to the fourth-year students. That is, it is designed as a four-year consecutive program. First, second, and third year students take a 50-minute class once a week for 30 weeks in an each academic year. In the fourth year, the class is offered for 90 minutes once a week for 15 weeks. In our Essential Thinking Classes, the "design thinking" process is the primary focus. Students are asked to solve real world problems through interviewing people outside their classrooms and suggest solutions and build prototypes to demonstrate their ideas. In addition, logical thinking and critical thinking activities are also introduced to the students to broaden their problem-solving skills. Every class requires group work in English which has been enhancing students' communication skills. Each class has approximately forty two students divided into 10 different groups with four or five

members. They are always encouraged to talk and help one another in their groups. Teachers in these classes are non-Japanese teachers. They give instructions and explanations in English. It is required for the students to express themselves in English. For more details about this essential thinking class, please refer to Ominato et al. (2021).

Methods

This study is follow-up research of our newly designed Essential Thinking classes in NITNC. Although the purpose of this class is to foster both students' generic skills and their English proficiency, we will focus more on the former. In our prior research (Ominato et al., 2021), it was found that there was no improvement (no significant difference) in their "cooperativeness", "creativity", nor "thinking ability" before and after their one-year experience in the academic year of 2020 (n=189). Ominato et al. (2021) conducted a questionnaire that directly asked students to rate their skills in four-point Likert. For more detailed consideration, in this recent study, we adopted evaluations from others in the class to determine students' generic skills.

A questionnaire was provided to the students online (*Microsoft* Forms) at the end of the school year in February 2022. It asked the students who they believed has the most "cooperative skills," "thinking skills," and "creativity," and why they thought so. The participants of this study were the first-year students (n=206) and the second-year students (n=209) who were taking Essential Thinking classes (English IC and English IIC) in the school year of 2021. Combined with this data, we used their PROG Test results. The first-year students took the PROG Test in June 2021, and the second-year students took it in August 2020 when they were in the first year of NITNC. Three students for each year were absent from school on those PROG Test dates, so those six students were excluded from the analysis.

First of all, we examined the reasons given by the students in selecting the person, this collective data can be definitions of "cooperativeness," "thinking ability," and "creativity" for NITNC students. The data was analyzed by using *User Local* text mining tool (https://textmining. userlocal.jp/). It shows word cloud, the number of word occurrences, and summaries of the key parts of students' responses. By an analysis of those data, we could identify the types or the most common description of students who they believe have cooperative skills, thinking skills, and creativity.

Second, we analyzed the difference of their PROG Test scores of the two different groups; the ones selected as students who had cooperative skills by their classmates and the ones who were not selected. We did the same for those selected for thinking skills and creativity as well. PROG Test evaluates students' generic skill (Competency), three core abilities (Teamwork skills, Personal skills, and Problem solving skills), nine further key elements, and their 33 detailed factors (sub-categories). The skills of Competency and nine key elements are measured at 1 – 7, and 33 detailed factors are measured at 1 – 5. Students with higher skills are assessed as higher levels. (Refer to the Appendix for more details.) Two-sided T-test was conducted on the figures of all those selected and not selected in both groups. If we can find significant differences between the selected and not selected, this information may illuminate the features of the students who others feel have "cooperative skills," "thinking skills," and "creativity" at least among students in NITNC.

Results and Discussion

<Definitions>

"Word cloud" is a method of selecting multiple words that occur frequently in a sentence and illustrating them in a figure with a size corresponding to their frequency. The Figure 1 is the word cloud for "cooperativeness," the Figure 2 is for "thinking skills," and the Figure 3 is for "creativity." In addition to that, we also examined the number of times each key word (nouns, verbs, and adjectives) appeared in the students responds (reasons for selecting their classmates) in the following Table 1 to 9.

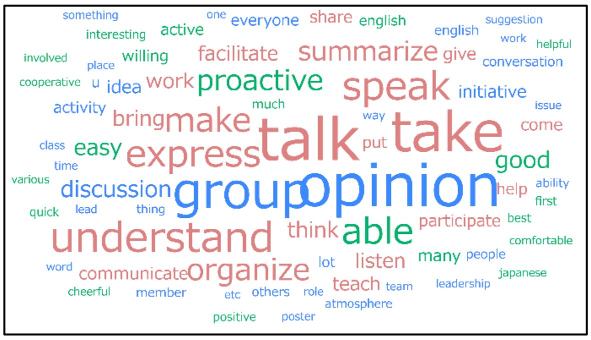

Figure 1. Word cloud for "cooperativeness"

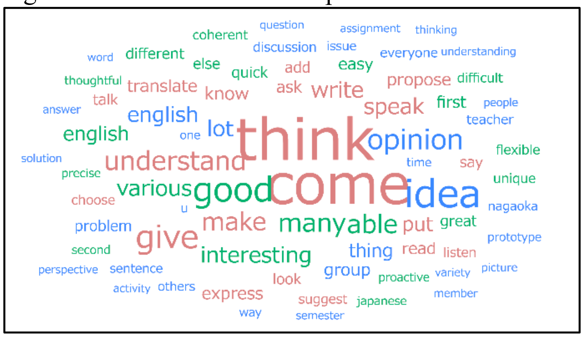

Figure 2. Word cloud for "thinking skills"

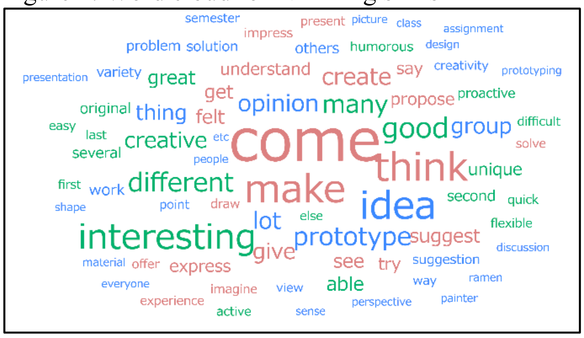

Figure 3. Word cloud for "creativity"

Table 1. Nouns: Frequency of word appearance in "cooperativeness"

	part of speech	word	the number of times it appeared
1	noun.	opinion	77
2	noun.	group	69
3	noun.	discussion	41
4	noun.	idea	27
5	noun.	initiative	24
6	noun.	everyone	21
7	noun.	activity	20
8	noun.	us	16
8	noun.	lot	16
10	noun.	conversation	12
10	noun.	english	12

Table 2. Verbs: Frequency of word appearance in "cooperativeness"

1	verb.	talk	31
2	verb.	take	30
3	verb.	understand	24
4	verb.	speak	23
5	verb.	express	22
6	verb.	make	21
7	verb.	organize	19
8	verb.	summarize	17
9	verb.	bring	16
9	verb.	think	16

Table 3. Adjectives: Frequency of word appearance in "cooperativeness"

1	adjective.	able	22
2	adjective.	proactive	18
3	adjective.	good	17
4	adjective.	easy	16
5	adjective.	many	9
6	adjective.	willing	8
6	adjective.	active	8
8	adjective.	english	6
9	adjective.	much	4
10	adjective.	quick	3
10	adjective.	interesting	3
10	adjective.	positive	3
10	adjective.	best	3
10	adjective.	first	3

Table 4. Nouns: Frequency of word appearance in "thinking skills"

1	noun.	idea	82
2	noun.	opinion	43
3	noun.	lot	20
4	noun.	english	19
5	noun.	thing	15
6	noun.	group	13
7	noun.	problem	10
8	noun.	discussion	7
8	noun.	teacher	7
8	noun.	everyone	7

Table 5. Verbs: Frequency of word appearance in "thinking skills"

1	verb.	think	59
2	verb.	come	55
3	verb.	give	24
4	verb.	understand	15
5	verb.	make	13
6	verb.	write	9
6	verb.	speak	9
8	verb.	put	7
9	verb.	know	6
10	verb.	translate	5
10	verb.	propose	5
10	verb.	express	5
10	verb.	ask	5
10	verb.	read	5

Table 6. Adjective: Frequency of word appearance in "thinking skills"

	part of speech	word	the number of times it appeared
1	adjective.	good	27
2	adjective.	able	14
3	adjective.	many	14
4	adjective.	interesting	9
5	adjective.	various	8
6	adjective.	english	7
7	adjective.	easy	5
8	adjective.	first	5
9	adjective.	quick	4
9	adjective.	else	4
9	adjective.	different	4
9	adjective.	great	4

Table 7. Nouns: Frequency of word appearance in "creativity"

	part of speech	word	the number of times it appeared
1	noun.	idea	88
2	noun.	prototype	32
3	noun.	lot	24
4	noun.	opinion	23
5	noun.	group	17
6	noun.	thing	15
7	noun.	work	8
8	noun.	others	7
9	noun.	variety	6
9	noun.	solution	6
9	noun.	problem	6

Table 8: Verbs: Frequency of word appearance in "creativity"

	part of speech	word	the number of times it appeared
1	verb.	come	63
2	verb.	think	36
3	verb.	make	35
4	verb.	create	9
5	verb.	give	7
6	verb.	suggest	5
6	verb.	felt	5
6	verb.	see	5
6	verb.	get	5
10	verb.	propose	4
10	verb.	express	4
10	verb.	understand	4
10	verb.	try	4
10	verb.	say	4

Table 9: Adjectives: Frequency of word appearance in "creativity"

	part of speech	word	the number of times it appeared
1	adjective.	interesting	28
2	adjective.	good	19
3	adjective.	different	15
4	adjective.	many	12
5	adjective.	creative	6
6	adjective.	able	5
6	adjective.	great	5
8	adjective.	unique	4
9	adjective.	original	3
9	adjective.	several	3
9	adjective.	second	3

Based on the information we gained from the Figures 1 to 3and the Tables 1 to 9, and also from the suggestions of *User Local* text mining tool, a student with each of the three skills can be describes as follows.

<Students with "cooperativeness">

They actively speak up in the group and turn the place around. They are able to express their opinions and engage in discussions. They also listen carefully to everyone's opinions and summarize them. They talk to various people in the group to deepen the conversation.

<Students with "thinking ability">

They come up with and give many good ideas and opinions that you would never think of because they can look at things from different angles.

<Student with "creativity">

They can have flexible ideas that no one can come up with. They can also come up with humorous ideas, and they make people laugh.

The result of the two-sided *T*-test (*n*=409) on students' PROG Test for selected students and not selected students is shown in Table 10. The maximum score on Competency, Teamwork skills, Personal skills, and 9 elements is seven, and the one on the 33 sub-categories (detailed factors) is five. For "cooperativeness", significant differences ($p<.01$) are found in Competency Results, Teamwork skills, Personal skills, Collaborating with others, Self confidence, Implementing solutions, Role understanding / cooperative action, Consultation / guidance / motivating others, and Understanding of identity. For "thinking skills, they are found in Competency Results, Teamwork skills, Personal skills, Self control, Behavior control, Trust building, Constructive / creative discussion, Practical action, and Correction / adjustment. Finally, for "creativity", Competency Result, Teamwork skills, Personal skills, Relating with other, Collaborating with others, Team management, Self control, Behavior control, Role understanding / cooperative action, Consultation / guidance / motivating others, Constructive / creative discussion, Stress management, Understanding of identity, Self-efficacy / optimism, and Subjective action showed significant difference between two groups. "Creativity" showed the most number of significant differences of fifteen whereas the others have nine.

From the result of this test, it may be said that the students with the three skills have the following characteristics.

<Cooperativeness>

Students who were rated as having high collaborative ability basically have high generic skills. Both teamwork skill and personal skill are high. They have collaborative skills and have confidence-generating and practical skills. They understand their own roles and are able to work with others. They are skilled at counselling, sometimes mentoring, and motivating other students. They also have a good understanding of their own uniqueness.

<Thinking Skills>

Students who are assessed as being thoughtful students have high basic versatility skills. Both teamwork and personal skill are high. They have good emotional control and the ability to sustain action, and they are skilled at building trusting relationships with others. They are able to engage in constructive and creative discussions and are skilful in putting into practice and action and in modifying and adjusting their own practices.

<Creativity>

Creative students are fundamentally versatile in their abilities. The difference between creative students and uncreative students is particularly significant in teamwork skills. They have the ability to control their emotions, sustain their actions, understand their own roles, and work with others. The student is able to counsel other students, sometimes mentor them, and motivate them. They are good at constructive and creative discussion, and are able to act independently. They are able to manage their own stress and have a sense of self-efficacy and optimism. They have a good understanding of their own uniqueness.

Conclusions

Overall, it can be said that the generic skills (competency) of the students who were selected by other students were significantly higher than the students who were not slected. There was a significant difference in the ability of "Collaborating with others" between the students who were slected to be highly cooperative and those who were not. Of the thirty-three detailed factors, significant differences were identified in three factors For cooperativeness, four factors for thinking ability, and seven factors for creativity. Therefore more skills are required in order to be considered as a creative person. In order to be considerd as both cooperative and creative, students need to understand their roles in their groups, to perform cooperative actions, to consultate, help, and motivate others. On top of that, it is important to note that only creativity showed significant difference in "stress management," "self-efficacy" and "subjective action." It is an urgent task for the faculty members of Kosen to seriously consider and work on the development of these abilities in Kosen students, and also it is a major issue for the future of Kosen education. The rusult of "thinking ability" shows interesting facts as well. The participants regarded students as having thinking ability if they were reliable (had trust building ability), practical, and even able to modify and adjust their own work. In these areas, Kosen has been doing great work in their education system to foster engineers for the future.

Because of the various limitations of this study, such as the size of the study population, we should be cautious about overgeneralizing the present results. Also, this study only shows how students feel about the other students regarding cooperative skills, thinking ability, and creativity. Hence, we have not been able to present

objective methods or numerical values that would indicate all the abilities we mentioned in this paper.

It is essential to improve our program to enhance our student's learning on the three skills we mentioned in this paper. For our future mission in Nagaoka Kosen, we would like to assess our students' improvement on their English abilities as well as their generic skills in detail.

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Appendix. Students' mean scores of the PROG Test and the *p*-value of the two-sided *T*-tests results between the selected and not-selected students

			Cooperativeness			Thinking Ability			Creativity		
			Selected	Not Selected	*T*-test	Selected	Not Selected	*T*-test	Selected	Not Selected	*T*-test
Competency Results			3.32	2.90	0.004 **	3.45	2.88	0.000 **	3.45	2.90	0.000 **
Three Core Abilities	Teamwork skills		3.74	3.25	0.004 **	3.82	3.27	0.002 **	3.86	3.27	0.001 **
	Personal skills		3.58	3.14	0.003 **	3.63	3.16	0.002 **	3.65	3.17	0.002 **
	Problem solving Skills		3.41	3.28	0.378	3.53	3.22	0.052	3.46	3.27	0.257
Nine Elements	Teamwork skills	Relating with others	3.73	3.41	0.071	3.79	3.41	0.043 *	3.95	3.34	0.001 **
		Collaborating with others	3.89	3.29	0.001 **	3.86	3.39	0.011 *	3.98	3.34	0.001 **
		Team management	3.49	3.19	0.081	3.59	3.18	0.022 *	3.68	3.14	0.003 **
	Personal skills	Self control	3.44	3.21	0.164	3.61	3.15	0.007 **	3.71	3.11	0.001 **
		Self confidence	3.56	2.97	0.000 **	3.46	3.10	0.025 *	3.43	3.12	0.064
		Behavior control	3.56	3.26	0.065	3.71	3.21	0.003 **	3.75	3.21	0.001 **
	Problem solving Skills	Problem identification	3.72	3.54	0.265	3.74	3.56	0.272	3.73	3.56	0.326
		Planning solutions	3.08	3.15	0.687	3.33	3.00	0.070	3.25	3.05	0.290
		Implementing solutions	3.65	3.26	0.007 **	3.64	3.32	0.027 *	3.51	3.39	0.457
33 Detailed Factors	Relating with others	Approachability	2.96	2.66	0.044 *	2.97	2.70	0.082	3.01	2.68	0.039 *
		Attentiveness	2.65	2.37	0.034 *	2.71	2.37	0.016 *	2.67	2.40	0.060
		Interpersonal interest/empathy/receptiveness	2.90	2.83	0.600	2.86	2.86	0.983	3.01	2.78	0.114
		Diversity understanding	3.22	3.25	0.854	3.19	3.26	0.638	3.28	3.21	0.652
		Building up a network of connections	2.81	2.65	0.256	2.79	2.68	0.437	2.88	2.64	0.098
		Trust building	3.03	2.75	0.062	3.19	2.70	0.002 **	3.07	2.77	0.061
	Collaborating with others	Role understanding/cooperative action	3.67	3.12	0.000 **	3.47	3.30	0.309	3.66	3.21	0.005 **
		Information sharing	2.78	2.66	0.378	2.76	2.69	0.621	2.92	2.61	0.034 *
		Mutual support	2.83	2.51	0.032 *	2.90	2.51	0.013 *	2.84	2.55	0.074
		Consultation/guidance/motivating others	2.81	2.41	0.008 **	2.82	2.45	0.021 *	2.88	2.43	0.004 **
	Team management	Talk to each other	2.81	2.67	0.291	2.79	2.70	0.501	2.91	2.64	0.038 *
		Express opinions	2.68	2.65	0.794	2.77	2.60	0.238	2.83	2.58	0.097
		Constructive/creative discussion	2.70	2.36	0.011 *	2.77	2.37	0.004 **	2.76	2.38	0.007 **
		Opinion coordination, negotiation, persuasion	2.72	2.57	0.281	2.79	2.55	0.075	2.78	2.56	0.134
	Self control	Self-awareness	3.51	3.33	0.257	3.34	3.45	0.476	3.38	3.43	0.758
		Stress coping	2.91	2.87	0.796	3.09	2.77	0.030 *	3.04	2.80	0.106
		Stress management	2.59	2.40	0.175	2.67	2.38	0.051	2.84	2.31	0.000 **
	Self confidence	Understanding of identity	2.88	2.47	0.003 **	2.82	2.55	0.058	2.90	2.52	0.009 **
		Self-efficacy/optimism	2.76	2.41	0.012 *	2.77	2.44	0.025 *	2.86	2.41	0.002 **
		Personal transformation by learning view/opportunities	2.28	2.12	0.206	2.18	2.19	0.968	2.08	2.24	0.217
	Behavior control	Subjective action	2.35	2.21	0.238	2.43	2.18	0.047 *	2.50	2.15	0.007 **
		Outworking	2.94	2.82	0.402	3.00	2.81	0.204	3.04	2.79	0.101
		Getting into the habit of positive actions	3.32	3.09	0.064	3.29	3.13	0.199	3.30	3.13	0.178
	Problem identification	Information collection	2.61	2.57	0.803	2.62	2.57	0.683	2.79	2.48	0.029 *
		Understanding of the essence	2.89	2.64	0.086	2.90	2.67	0.109	2.78	2.74	0.805
		Cause investigation	2.70	2.57	0.311	2.55	2.67	0.339	2.69	2.60	0.494
	Planning solutions	Goal setting	2.29	2.38	0.489	2.47	2.27	0.155	2.34	2.34	0.986
		Scenario modeling	2.38	2.44	0.608	2.62	2.30	0.013 *	2.54	2.35	0.143
		Plan assessment	2.58	2.61	0.841	2.68	2.55	0.357	2.57	2.61	0.785
		Risk analysis	2.38	2.49	0.415	2.51	2.40	0.463	2.43	2.45	0.895
	Implementing solutions	Practical action	2.72	2.48	0.082	2.83	2.45	0.007 **	2.67	2.54	0.385
		Correction/adjustment	2.53	2.35	0.184	2.68	2.29	0.005 **	2.57	2.36	0.141
		Verification/improvement	3.14	2.80	0.019 *	2.94	2.95	0.916	2.93	2.96	0.835

*$p<.05$, **$p<.01$

Online Classroom for Programming Contest Using Scratch for Introductory Education

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Abstract

In recent years, online classes have been offered at the school due to the COVID-19. Our school offers a class called Introduction to Professional Design as an introductory education for first-year students. This class aims to motivate students through exercises before learning the specialties of each department. In the Department of Electrical and Computer Engineering, a programming contest using Scratch has been held in six classes and has been conducted online using Microsoft Teams for the past two years, and the students' feedback on the class has been positive, saying that they enjoyed it. In this paper, we describe the lesson plan for the programming contest held in the online class and introduces the students' actual works.

Keywords: *online classes, online programming contest, introductory education, class contents, Scratch*

Introduction

In recent years, online classes have been offered at the school due to the COVID-19. Our school offers a class called Introduction to Professional Design as an introductory education for first-year students. This class aims to motivate students through exercises before learning the specialties of each department. In the Department of Electrical and Computer Engineering, a programming contest using Scratch has been held in six classes and has been conducted online using Microsoft Teams for the past two years, and the students' feedback on the class has been positive, saying that they enjoyed it. This paper describes the lesson plan for the programming contest held in the online class and introduces the students' actual works. They can program games while having fun. In the programming contest, each group was divided into 10 groups of 4 members, and through the creation of the game, chat rooms and online meetings were held to facilitate online communication, and the roles were assigned to each group to ensure efficiency and success. The students worked to produce their works in an efficient manner. Some of the works were of a quality far beyond the faculty's imagination. The 15-minute explanatory video at the beginning of the introduction of the first class has been uploaded to the class material sharing website of the Organization of National Colleges of Technology and can be freely used by KOSEN's teachers. In the future, it is highly likely that online classes will become the norm due to the spread of coronavirus infection, and the sharing of teaching material videos that anyone can use in class is important from the standpoint of improving the efficiency of class material preparation. In addition, as a future issue, we will discuss how to make the classes proceed, as it was often difficult to have smooth communication in online classes.

Class Contents

Our school offers a class called Introduction to Professional Design as an introductory education for first-year students. This class aims to motivate students through exercises before learning the specialties of each department. In the Department of Electrical and Computer Engineering, a programming contest using Scratch has been held in six classes and has been conducted online using Microsoft Teams for the past two years, and the students' feedback on the class has been positive, saying that they enjoyed it. Table 1 shows class contents. In the first class, an introduction is given, the formation of the group is explained, and the members are asked to discuss online what kind of work they will create together. In this case, we register the members of each group in a private channel in Microsoft Teams, where they can chat and videoconference with each other (Figure 1).

Table 1: Class Contents

Lessons	Class contents
Lesson 1	Introduction
Lesson 2	co-work of programming 1
Lesson 3	co-work of programming 2
Lesson 4	co-work of programming 3
Lesson 5	Programming contest
Lesson 6	Reporting

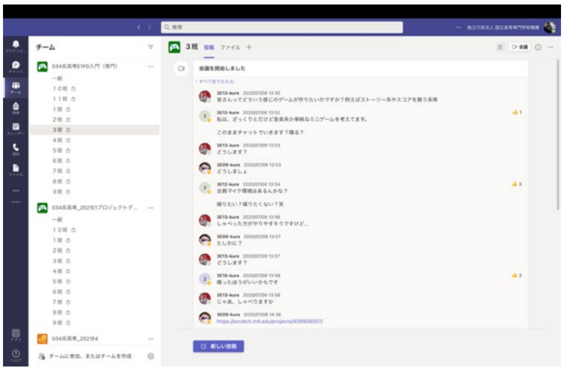

Figure 1: Group Discussion

The video of the introductory part of the first class is available on the website of the National Institute of Technologies (NIT) headquarters for the exclusive use of faculty members and staff.

In the three classes from the second to the fourth session, each group produced a co-work for the programming contest (Figure 2). Many of the group members enjoyed working together outside of class time to complete their projects using Scratch [1]. In each class, each student was asked to report on the progress of what work they had done using Microsoft Forms.

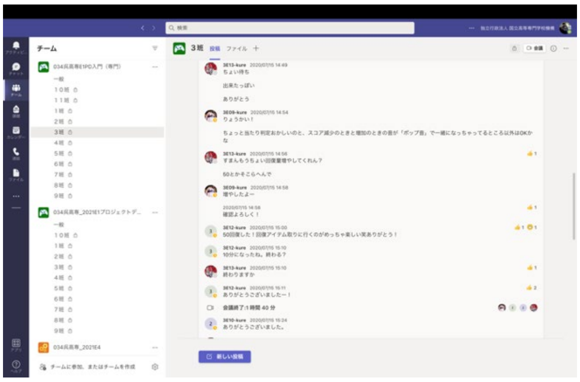

Figure 2: Co-work of Programming

Programming constst was conducted in the 5th class. Each group had 7 minutes to present their work, and students mutually rated each other's work on a 5-point scale, except for the group to which they belonged. At that time, we asked each student to upload their work to a shared file space so that they could enjoy their work. Finally, we asked the students to send a free-text description of the work of the group that impressed them the most and the reasons why and provided this information to the members of each group.

In the 6th class, the students were asked to write a report as a summary. In the report, each group member was asked to summarize which part of the work they oversaw and what kind of innovations they made.

Introduction of Works Produced

In this section, we present the works created by the first-year students in their respective groups. The students have completed wonderful works beyond our imagination in the limited production period of one month.

Pencil and line (4th group): Use a pencil to draw a line to carry the ball to the goal! Hold down the mouse button and drag to draw a line. Once the line is drawn, press A to execute. The longer you keep drawing the line, the shorter the pencil gets. However, the ball only moves down and to the right. If the ball gets stuck, you can start over by pressing the right arrow key (Figure 3).

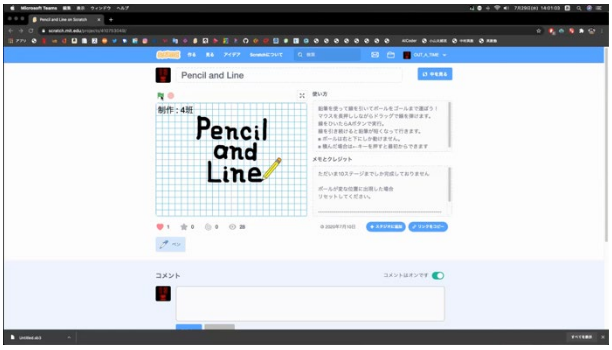

Figure 3: Pencil and Line

The game consisted of 10 stages, and the difficulty level increased as the stages progressed; the background music was also prepared, and I was surprised at the high level of perfection of the game. The students also gave the highest score of 4.9 in their peer evaluation.

EARTHshooting (9th group): This is a shooting game. Move your ship with the mouse and click to fire bullets. The HP starts at 100 and decreases as the ship hits invaders and obstacles, and when it reaches 0, the game is over. The boss appears when the HP is less than 20 and 80 or more invaders are destroyed. The roles of this group were divided among those in charge of game production, character design, background music, sound effects, and mini-games, and the difficulty level gradually became more difficult. The game was easy to operate with the mouse, and the sound effects were set at a fast tempo because of the heavy motion. The students also gave the second score of 4.61 in their peer evaluation.

Conclusions

In this paper, we descibed on regarding six online lessons for a programming contest for introductory education to first-year students. In the first year, the class was face-to-face for one week and then online for the rest of the lessons, allowing the first-year students to complete a piece of work in a short period of time through online collaboration with members they did not know very well.

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An Evaluation of Work Study Programme (WSP) in Specialist Diploma in Supply Chain Management in Republic Polytechnic

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Abstract

In this paper, we present the key findings of a study conducted to determine the effectiveness of Republic Polytechnic's Work Study Programme (WSP) in Specialist Diploma in Supply Chain Management (SDSCM) in upscaling the participants' competencies in the workplace. This study was conducted due to emerging concerns about logistic education and training gaps in meeting the needs of the logistic workforce. In particular, we examined the following aspects of the WSP: (i) Participants' perception of knowledge and skills attained in SDSCM; (ii) Participants' perceived usefulness and challenges faced in SDSCM; (iii) Participants' motivation in enrolling into SDSCM under WSP; (iv) The extent in which the participants apply the knowledge and skills attained from SDSCM at the workplace. This study was conducted using quantitative surveys and qualitative Focus Group Discussion (FGD) with a sample size of 87 on a one-year SDSCM course. The results revealed that participants generally perceived that their knowledge and skills in this field have improved after completing the SDSCM and applied them at the workplace. Furthermore, financial incentives from the government and interest in upskilling appeared to be the most significant motivating factors for participants to enrol into WSP. However, the participants also shared some challenges they faced participating in this programme. Finally, we concluded this paper with recommendations to improve the design and delivery of this course based on the findings of this study.

Keywords: *Work Study Programme, supply chain management, logistics, upskilling, workplace application, motivating factors*

1. Introduction

A study conducted by Wong (2018) across 93 countries revealed that education is one of the critical components affecting logistic performance. Yoon (2016) also highlighted that logistics has grown in volume and the evolution in themes, theory, and methods to reflect and analyse these changes. However, evidence shows the shortfall in the current logistic education and training, failing to keep up with these rapid changes. For instance, Mangan (2010) suggested that the existing supply of education and training is not perceived as fully meeting present or future needs.

To forge a more vital linkage between the curriculum taught in institutes of higher learning and the needs of the workplace, the Singapore government launched WSP in 2015. This was initially named Earn and Learn Programme to encourage eligible Singaporeans or Singapore Permanent Residents to enrol into relevant workplace courses to upskill themselves while being employed. Considering the need to ensure logistic education and training remains relevant, we examined the effectiveness of Republic Polytechnic's (RP) WSP in SDSCM in meeting the industry demand.

2. Project Description

The coverage and relevance of the course content are critical in enabling the participants to meet the industry's need in logistics (Mangan, 2010). As such, this study has a duo focus. First, we analysed the course content and examined its relevance. Second, we examined the participants' motivation in enrolling on the course.

2.1 Research Questions:

The following research questions guide this study:

(a) What was the participants' perceived knowledge and skills level before and after the course?

(b) To what extent did the participants apply the knowledge and skills attained in this course at their workplace?

(c) What was the main reason(s) participants enrolled for this course?

(d) What were the aspects of this course that participants deemed challenging?

2.2 Methodology

The SDSCM course under WSP consisted of nine logistic modules and one capstone project. For this study, we recruited participants who commenced this course in October 2018 and 2019. A total of 87 participants took part in this study.

We crafted a questionnaire to gather the quantitative input from the participants. The questionnaire consisted of 40 survey items to measure the following:

- Self-rating of their knowledge and skills level in each module of SDSCM before and after the course
- Frequency of application of the knowledge and skills in each module of SDSCM at work
- The extent to how different factors (e.g. financial incentive, upskilling, etc.) influenced their decision to enrol on this course
- The level of challenges faced in completing each module of SDSCM
- The main issue(s) encountered in completing the course

Three sessions of FGD were also conducted with 10 participants. The FGD intended to gather insights from participants on the following:

- The positive and negative experiences they had in this course
- Challenges they faced in completing this course
- Suggestion on how this course can be improved

3. Results and Discussion

3.1 Attainment of Knowledge and Skills

Participants were asked to self-rate their knowledge and skills on each SDSCM module using a 5-point Likert scale (1 being lowest and 5 being highest) before and after each module. Statistical T-test analysis was conducted to assess any significant difference in their self-rating of knowledge and skills level before and after the course. Table 1 summarises the results of the analysis.

Table 1. Participants' self-rating on their knowledge and skills level (n = 87)

Module	Self-rating on Knowledge/Skills BEFORE the course (mean ± stdev)*	Self-rating on Knowledge/Skills AFTER the course (mean ± stdev)*	*p*-value (α = 0.05)
Warehouse Management and Operations	3.24 ± 1.0	4.24 ± 0.59	1.1 E-14
Transportation Management and Operations	3.1 ± 1.09	4.26 ± 0.6	1.6 E-17
Freight Services and Operations	2.85 ± 1.01	4.14 ± 0.61	4.2 E-20
Inventory Management	3.25 ± 0.98	4.26 ± 0.62	1.8 E-17
Enterprise Resource Planning	2.72 ± 1.18	4.06 ± 0.67	1.5 E-17
Pharmaceutical and Cold Chain Management	2.76 ± 1.19	4.16 ± 0.64	9.4 E-20
Lean Processes and Simulation	2.84 ± 1.07	4.08 ± 0.69	8.8 E-28
Supply Chain IT	2.69 ± 0.93	4.10 ± 0.63	2.0 E-23
Supply Chain Design and Management	2.86 ± 1.01	4.11 ± 0.62	2.2 E-19

**results presented in the form of (mean ± standard deviation) for rating scale of 1-5.*

The consistently low *p*-value (much less than the standard 0.01) in Table 1 indicates that the statistical difference between participants' self-rating before and after the course is significant. This result is expected as most participants may not have the prior knowledge on certain subject matter before starting the course.

3.2 Application of Knowledge and Skills

The participants were asked to indicate the frequency in which they applied the knowledge and skills related to the nine logistic modules of SDSCM at work. The results of their indication are presented in Table 2.

The results showed that, in general, the course participants did utilise the content knowledge covered in SDSCM quite frequently at the workplace. This is hardly surprising given the business nature of the companies and the course participants' job scope.

Table 2. Participants' indication on the frequency of application of their knowledge and skills related to SDSCM modules (n = 87)

Module	Never (%)	Sometime (%)	Often (%)
Warehouse Management and Operations	14.9	25.3	59.8
Transportation Management and Operations	10.3	48.3	41.4
Freight Services and Operations	20.7	41.4	37.9
Inventory Management	19.5	26.4	54
Enterprise Resource Planning	27.6	40.2	32.2
Pharmaceutical and Cold Chain Management	50.6	27.6	21.8
Lean Processes and Simulation	26.4	44.8	28.7
Supply Chain IT	21.8	58.6	19.5
Supply Chain Design and Management	24.1	54	21.8

3.3 Incentives for Enrolling into the Course

The participants were asked to indicate how each of these factors influenced their decision to enrol for this course:

- Financial Incentive of SGD$5,000
- Upskilling of Knowledge/Skills
- Attainment of Specialist Diploma Certificate
- Articulation with University
- Company's Directive/Suggestion
- Recommendation by Others

In addition, they were also asked to indicate up to three main reasons from the list that attracted them to enrol for this course. Table 3 and Figure 1 summarise the results of these two findings.

It was evident that financial incentive, interest in upskilling, and desire to attain a specialist diploma certificate are the top three motivating factors that influenced the participants to enrol for this course.

3.4 Challenges Encountered in the Course

The course participants were asked to indicate the main challenges encountered in completing this course. Their indication is presented in Figure 2.

The results showed that 95.4% of course participants found it challenging to juggle work and study. However, it was positive that 83.4% of them completed the course in their first attempt.

3.5 Overall Benefits of the Course and Participants' Feedback

The course participants were asked to rate the overall benefits of this course. Figure 3 summarises this result. 96.5% of the participants regarded the benefits of this course highly. We corresponded this result with the data gathered from the FGD sessions. The participants shared that they were content with the quality of lecturers, mentors, and resources provided in this course. However, they suggested that the following aspects of the course be improved:

- Support from the work supervisors for the On the Job Training component of this course.
- Completion date of this course can be adjusted to be nearer the enrolment date of university.
- Communication and coordination between the course trainer/supervisor and their work supervisor.

Table 3. Participants' indication on the extent of how different factors influenced their decision in enrolling into the course (n = 87)

Factors	Not at All (%)	Barely (%)	Somewhat (%)	Quite a Large Extent (%)	Very Large Extent (%)	Not Applicable (%)
Financial Incentive of SGD$5,000	4.6	5.7	29.9	36.8	16.1	6.9
Upskilling of Knowledge/Skills	1.1	1.1	27.6	50.6	19.5	0.0
Attainment of Specialist Diploma Certificate	1.1	9.2	29.9	43.7	16.1	0.0
University Articulation	10.3	16.1	34.5	27.6	11.5	0.0
Company's Directive/Suggestion	17.2	6.9	19.5	10.3	8	37.9
Recommendation by Others	11.5	14.9	21.8	14.9	10.3	27.6

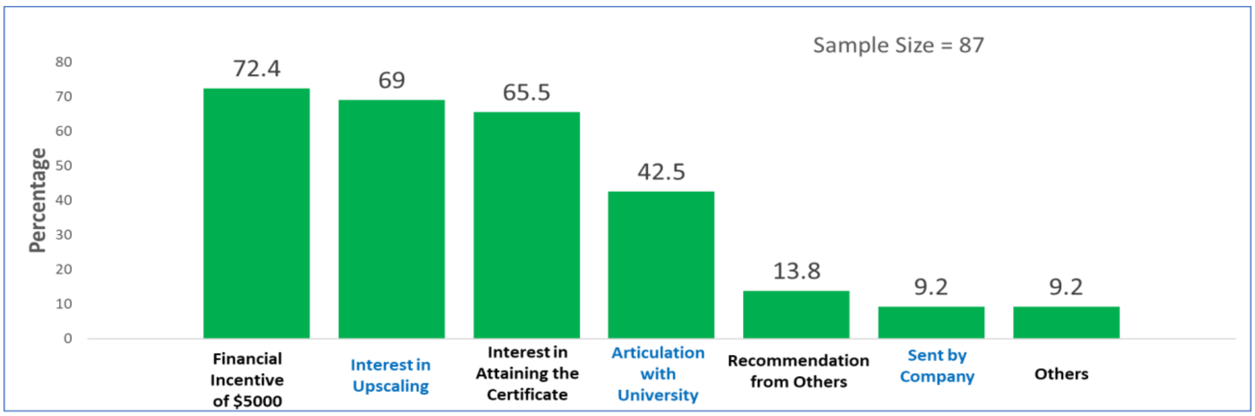

Figure 1. Participants' indication of main factors that attracted them to enroll for the course (n = 87)

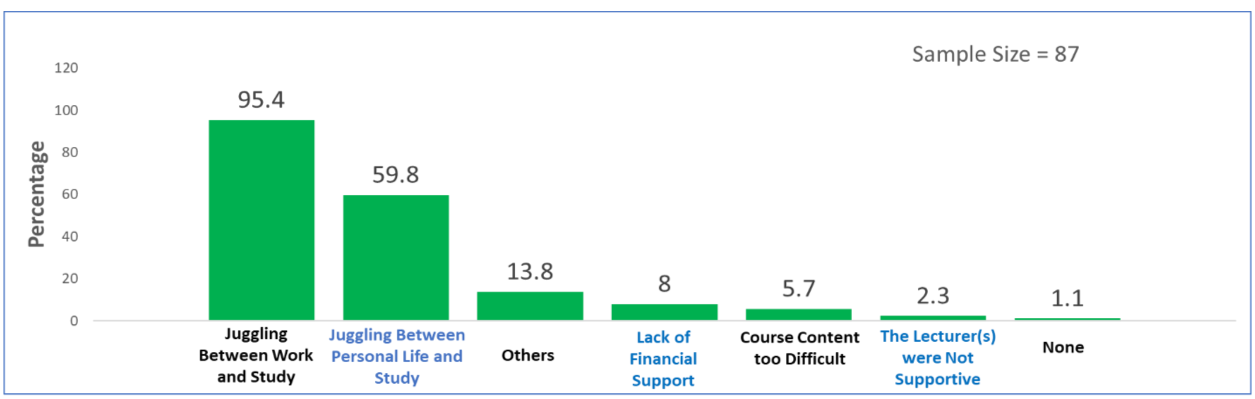

Figure 2. Participants' indication of challenges faced in completing the course (n = 87)

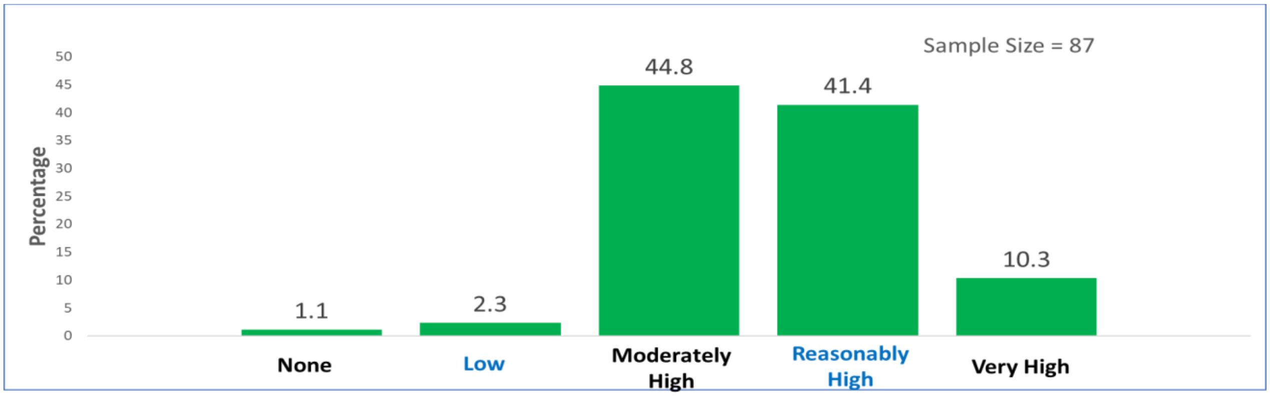

Figure 3. Participants' rating on the level of benefit of the course (n = 87)

4. Conclusion

The main finding of this study suggests that financial incentive from the government plays a significant role in attracting employees to enrol into the WSP. The course participants acknowledged attaining new knowledge and skills in logistics through this course. They were also able to apply the knowledge and skills attained at the workplace. Thus, we concluded that this course was effective in meeting the industry demand from the perspective of the course participants.

4.1 Recommendation on Course Design and Delivery

This study uncovered that conflicts between work and study appear to be the course participants' major challenge. Further, the FGD revealed specific issues on the support given to the participants in the On-the-Job Training component. Therefore, we proposed that course providers consider the following two recommendations:

(a) Review of lesson timing of this course to achieve a more optimal lesson timing in minimising the conflict between work and study for both the companies and the course participants.

(b) Enhance the support given to the course participants in the On-the-Job Training component. This can be done by providing adequate training to the work supervisors or improving the communication between the trainers of this course and the work supervisors. The communication between these two parties will enhance the consistency in how the On-the-Job Training is implemented.

4.2 Limitations and Future research

As this study was carried out with the SDSCM course at RP, it may not represent a comprehensive picture of logistic education and training in other educational institutions in Singapore. Further, this study only examined the effectiveness of the course from the perspective of the participants and not the participating companies. So, for a more comprehensive evaluation of this course, a similar study from the companies' perspective can be carried out in the future.

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EFFECTIVENESS OF BUSINESS ESSENTIALS THROUGH ACTION MODULE IN DEVELOPING ENTREPRENUERIAL THINKING

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Abstract

This study aims to examine the effectiveness of our newly developed year-long module, Business Essentials through Action (BETA), in promoting entrepreneurial thinking. BETA is an integrated foundational module where students go beyond acquiring the theory in marketing, human resource practices, business negotiation, entrepreneurship and design thinking to practicing them in a real business where they develop, launch and manage. The paper first discusses the importance of entrepreneurial mind set, particularly, entrepreneurial method, in today's volatile, uncertain, complex and ambiguous (VUCA) world. Then it describes the methodology of entrepreneurial method that is employed in designing BETA. Qualitative studies, particularly the Personal Entrepreneurial Competencies (PEC) instrument adapted from Azarcon and Roy (2008), was used to evaluate the effectiveness of BETA. A total of 68 first year Diploma in Common Business Programme (DCBP) students took part in this research, with 32 of them taking BETA while the rest of 36 students, acting as the control group, took the equivalent modules. A t-test was used to compare students' change in PEC scores within the two groups at 5% significance level and statistically it was found that BETA improved 9 out of 10 PEC as compared to Non-BETA where the improvement is 7 out of 10 PEC. T-test results using Welch t-test to compare the PEC between the two groups demonstrated that BETA is more effective in promoting the entrepreneurial thinking, especially in the 5 competencies detailed in the paper, such as Opportunity Seeking and Initiative, Systematic Planning and Monitoring, Persuasion and Networking, Persistence and Independence & Self Confidence. It was also noted that the equivalent modules do not improve Independence & Self Confidence unlike BETA curriculum. With these findings, recommendations are henceforth, proposed which are elaborated towards the end of the paper. As the study only focused on examining the entrepreneurial competencies, it is noteworthy to consider other variables and other qualitative methods in order to point us to a richer insights and feedback.

Keywords: *Creative, Entrepreneurial competences, Entrepreneurship, Self-Confidence, Self-directed Learning, Opportunity Seeking, Initiative, Systematic Planning and Monitoring, Persuasion and Networking, Persistence*

Introduction

Entrepreneurship education plays a critical role in providing students with the necessary skills and content knowledge to collaboratively develop products and services in a rapidly changing technological and market environment (Alusen, 2016). An entrepreneurial mind set, particularly, entrepreneurial method, are essential in the education. According to Sarasvathy (2011), entrepreneurial method refers to how entrepreneurs go about solving problems as they create new markets and opportunities. In order to develop entrepreneurial mindset in students, we need to move beyond teaching students concepts and skills to consider having students to engage in real experiences during which they practice entrepreneurial method. With that, Business Essentials Through Action 1 & 2 modules (BETA) were conceived.

Purpose of study

The purpose of this study is therefore, to examine the effectiveness of BETA in promoting entrepreneurial thinking. We will be exploring the development of entrepreneurial competencies across BETA and Non-BETA students. With that, we hope to provide recommendations to promote specific entrepreneurial competencies that may be lacking in our students.

Specifically, this study aims to:

1. explore the development of entrepreneurial competencies across BETA and Non-BETA students;
2. determine the strong competencies as well as those that require more attention in both BETA and Non-BETA students; and
3. provide suggestions on how to improve students entrepreneurial competencies especially on the weak ones in both BETA and Non-BETA students.

Literature review

With the proliferation of courses around entrepreneurship, Florian et al., (2007) discovered that majority of such courses focused on equipping potential entrepreneurs with the technical know-how to successfully start up a venture. Alongside these technical competencies, the current pedagogy also lends a strong emphasis on cultivating an entrepreneurial mindset, recognising the importance and transferability of such mindset in different career aspirations among students.

Neck & Greene (2011) started the assumption that the nature of entrepreneurship is neither linear nor predictable. In fact, entrepreneurship is a journey that requires entrepreneurs to navigate the uncertainties and make decisions by taking calculated risks based on incomplete information or resources. To meet such a requirement, the entrepreneurial method should be one that integrates two modes of logic to respond to both knowable and unknowable situations.

Neck et al., (2014) further propose a pedagogical shift in teaching entrepreneurship as a method in order to enable the integration of theory and practice. Such an entrepreneurial method is established from the practice of real entrepreneurs. Thus, teaching entrepreneurship as a method will requires students to engage in real experiences where they get to integrate theory and practice. Aside to the experience, Neck et al., (2014) asserted that helping students reflect on this experience is equally important for them to successfully learn the core principles behind such entrepreneurial method.

In 2018, a year-long module, BETA, is conceived to equip students with business fundamentals through the context of venture creation. This module is designed according to the entrepreneurial method highlighted by the literature. Reference was made to a first-year undergraduate programme offered by Babson College, Foundations of Management and Entrepreneurship (FME) where all first-year undergraduate students at Babson participates in the course, which includes an ideation and design thinking phase to develop an idea or initiative, followed by formation into companies, which develop, launch and manage a venture with real products and services (Brush, 2021).

After 2 years of preparation, Singapore Polytechnic School of Business piloted its first run of BETA in 2020, with 2 classes of students from the Diploma in Common Business Programme (DCBP). BETA is designed to help students experience the nature of business as an integrated enterprise where they learn Fundamentals of Marketing, Business Negotiation Studies and Management and Human Resource Practices.

Aligned with the institution's review and development of graduate attributes, BETA not only seeks to deepen domain competencies, but also to cultivate important qualities in students as they develop greater awareness around self, team and at organisational level. Through a practice-based approach, we hope to also cultivate leadership skills and personal effectiveness in the students where they practice, demonstrate, and acquire the skills of being a self-directed learner.

The BETA programme is divided into 4 terms across 2 semesters. In the first term, focus is placed on having student (comprising of 4-5 members per team) coming together to conceive an idea in which they would like to pursue. This is then followed through with a proof-of-concept presentation where 1 team in each class will be eliminated. In the second term, student teams acquired new knowledge on Marketing where they worked towards putting together a business proposal applying what they have learned in Marketing on their conceived business ideas. Following which, another team is dissolved, leaving 2 teams of 9-10 students entering the second semester.

In the second semester, each student team is given a loan amount to implement and operate their business. This requirement allows students to put what they have planned and proposed into practice.

By taking actions, students learned how to readily respond to changes – ranging from managing group dynamics, to reviewing product propositions; from rethinking operational workflows to relooking at planned Marketing initiatives. They learned the need to be resourceful, resilient, and adaptable.

In the design of BETA, we seek to assimilate change and how our students can adapt to changes in a controlled learning environment; providing students a context to actively experience knowledge instead of passively absorbing knowledge. It also created multiple learning moments for lecturers to partner student teams on experimentation, reflection and making improvements to their businesses – allowing for opportunities to cultivate in students an entrepreneurial mindset.

In evaluating the effectiveness of the BETA programme, reference is made to the Personal Entrepreneurial Competencies (PEC) questionnaire. PEC is a set of qualities, which outlines the attitude and behaviour of entrepreneurs (Alusen, 2016).

In 1989, MSI (Management Systems International) in partnership with McBer & Company, conducted research and identified ten personal entrepreneurial competencies (PECs). These are opportunity seeking, risk taking, persistence, demand for efficiency and quality, commitment to work a contract, information seeking, systematic planning and monitoring, persuasion and networking, goal setting, and self-confidence. From the research, MSI also came out with a self-rating questionnaire which can be used to assess an individual's likelihood of succeeding in the field of entrepreneurship. Since then, this questionnaire has been used by other researchers to determine the relationship of the personal entrepreneurial competencies.

Cited by Azarcon and Roy (2008), the PEC questionnaire, adapted from the original work of Management Systems International and McBer and Company, is being used as the first exercise in an introductory entrepreneurship course in a Philippine state university. The intention of using the PEC questionnaire is (1) to find out the entrepreneurial competencies that

students possessed, and (2) to identify which of the competencies do students not inherit before they are exposed to entrepreneurship education. The PEC questionnaire hence provides a very good indication of a student's personal entrepreneurial competencies.

Methodology of the research

In our attempt to measure the effectiveness of BETA on developing entrepreneurial competencies in students, student-respondents were requested to complete the PEC questionnaires before admitting to Singapore Polytechnic Business Course (Pre-Y1) and one year into the course (Post-Y1). Student-respondents' scores per entrepreneurial competency and the overall PEC scores were then computed. A correction factor is administered as an adjustment to the scores for respondents who presented very favourable image of himself or herself.

Two groups of students-respondents are involved in this study. The first group consists of 32 first year DCBP students who were involved in the pilot-run, taking BETA in AY2020/2021. The second group, serving as the control group, comprises of 36 first year Diploma in DCBP students randomly selected who undergo the usual teaching method. We will refer to the former group as BETA and the latter group as Non-BETA respectively for the purpose of this research.

PEC scores were analysed using Microsoft Excel 2017 while non-parametric t-test was used for analysis between groups via statistical software, Minitab. With our sample sizes (N) greater than 30, according to the central limit theorem, it holds true that our sampling distribution of the sample means approaches a normal distribution.

Results and discussion

Figure 1 shows the overall PEC scores for BETA and Non-BETA group at both instances, Pre-Y1 and Post-Y1. Both groups have the similar initial PEC scores prior to entering SP. It can be noted that there is a greater improvement in the overall PEC scores for BETA, with an improvement of 10%, from a PEC score of 158 to 174, compared to Non-BETA group with an improvement of 5%, from a PEC score of 158 to 166.

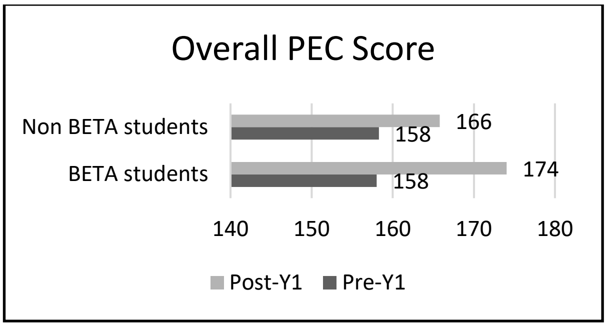

Figure 1. Overall PEC scores for BETA & Non-BETA groups Pre-Y1 and Post-Y1

Table 1 summaries the t-Test Paired Two Sample for Means within two groups: BETA and Non-BETA. Using a 95% confidence interval, it is noted that BETA could potentially improve 9 out of 10 PECs in students, namely, Opportunity Seeking and Initiative, Demand for Excellence and Quality, Persistence, Commitment to the Work Contract, Information seeking, Goal setting, Systematic Planning and Monitoring, Persuasion and Networking and Independence & Self Confidence, while the Non-BETA group shown potential improvements in 7 out of 10 PECs, namely Opportunity Seeking and Initiative, Demand for Excellence and Quality, Persistence, Information seeking, Goal setting, Systematic Planning and Monitoring and Persuasion and Networking. It would mean that the key difference between BETA and Non-BETA is that BETA promotes persistence, commitment to the work contract and independence and self-confidence.

In general, the majority of the PEC scores improve for both groups, except for risk taking competency in the Non-BETA group where the Post-Y1 is lower than the Pre-Y1. This could potentially mean that the current curriculum does not assist in improving the risk-taking competency in students.

The above correlates with findings by Kyguolienė and Švipas (2019), which could be attributed to the nature of the BETA module. In the context of venture creation, BETA students are required to pitch their ideas in convincing a panel of assessors on the desirability, viability, and feasibility of their business propositions. Students are required to actively find means on improving their businesses – from securing partnerships or improving operations, to optimising marketing efforts and establishing new profit models. The need to find customers and establish a stable customer base is essential in the context of a start-up. Given that actual money is involved, students feel an obligation to ensure that they can (at the very least) breakeven. As such, it calls a great amount of persistence, hard work and even persuasion and networking in launching a venture.

Our findings showed that risk-taking competency was also noted to be the least improved competencies in both groups. In the research done by Bautista, Barlis and Nazario (2007), it was found that Risk-taking competencies among students were also the weakest. This could potentially mean that risk-taking competency may not be an easy competency to develop among students.

Table 2 presents the t-test results using Welch t-test to identify if there is any significant improvement in PEC comparing the two groups: BETA and Non-BETA. Using a 95% confidence interval, it can be noted that BETA is more effective in promoting entrepreneurial thinking, compared to Non-BETA, with the p-value for overall PEC score being less than our alpha, 0.05. BETA, in comparison to Non-BETA, could potentially improve the following 5 competencies, namely, Opportunity Seeking and Initiative, Systematic Planning and Monitoring, Persuasion and Networking, Persistence and, especially for Independence & Self Confidence.

Table 1. t-Test Paired Two Sample for Means within two groups: BETA and Non-BETA

Personal Entrepreneurial Competencies	t-test for BETA students			t-test for Non-BETA students		
	t-statistic	Degree of freedom	p-value (one tail)	t-statistic	Degree of freedom	p-value (one tail)
Opportunity Seeking and Initiative	5.6621	31	<0.0005	3.2297	35	0.0013
Risk taking	0.8005		0.2148	-0.1012		0.4600
Demand for Excellence & Quality	3.6091		0.0005	3.6138		0.0005
Persistence	4.5328		<0.0005	1.7707		0.0427
Commitment to the Work Contract	1.7439		0.0455	1.1562		0.1277
Information seeking	3.6458		0.0005	3.0359		0.0023
Goal setting	2.7089		0.0054	3.0829		0.0020
Systematic Planning & Monitoring	3.6711		0.0005	3.4542		0.0007
Persuasion and Networking	3.9903		0.0002	2.7047		0.0052
Independence & Self Confidence	3.1083		0.0020	1.5404		0.0662

As we noted that there is no significant improvement in this one competency, Independence & Self Confidence, for Non-BETA group as shown in Table 1, there is significant improvement in this competency for BETA students when we compared across the two groups in Table 2. This could be attributed to the autonomy given to the students as they run their own businesses. Through the design of BETA, students exhibited a greater sense of ownership and belonging when they conceived, implemented, and managed their businesses. Such autonomy to run a business, be it from operations to marketing (where students put up content and generate sales) or to human resource management, (where students conduct peer learning and performance appraisals in class) provides students the opportunity to develop independence and self-confidence.

Table 2. t-test results using Welch t test to compare the PEC between the two groups: BETA and Non-BETA

Personal Entrepreneurial Competencies	t-test		
	t-score	Degree of freedom	p-value (one tail)
Opportunity Seeking &	2.35	61	0.011
Risk taking	0.69	60	0.245
Demand for Excellence & Quality	0.75	58	0.227
Persistence	2.87	53	0.003
Commitment to the Work Contract	0.77	56	0.222
Information seeking	0.80	63	0.213
Goal setting	0.81	50	0.212
Systematic Planning & Monitoring	1.75	45	0.043
Persuasion and Networking	2.41	45	0.01
Independence & Self Confidence	1.70	55	0.048
Overall PEC score	**1.99**	**51**	**0.026**

Summary of findings

This research comparing developments of entrepreneurial competencies across BETA and non-BETA students is an important affirmation to the pedagogical developments at Singapore Polytechnic School of Business towards an entrepreneurial method combining both causation and effectuation logics.

Our study of the developments of personal entrepreneurship competencies from student-respondents, henceforth concludes the following:

1. BETA has a greater improvement in all the 10 competencies as compared to Non-BETA group.
2. Risk taking competency did not improve in the Non-BETA group. This could potentially mean that the current curriculum does not assist in developing risk-taking competency in students.
3. BETA could potentially improve 9 out of 10 PECs in students as compared to Non-BETA where the improvement is 7 out of 10 PECs; Commitment to the Work Contract and Independence & Self Confidence did not have any significant improvement in Non-BETA students.
4. BETA is more effective in promoting the entrepreneurial thinking, compared to Non-BETA, especially in the following competencies, Opportunity Seeking and Initiative, Systematic Planning and Monitoring, Persuasion and Networking, Persistence and Independence & Self Confidence.
5. Independence & Self Confidence is the one competency that stands out for BETA group, compared to Non-BETA group.

Recommendations

Based on the results of our study, the following are recommended:

1. To consider having BETA as a compulsory module for all Year 1 Business students.
2. In the event where having BETA as a compulsory module is not feasible, to consider having an elective where students can embark on a mini business venture or a challenge where students get to conceive and

pitch their business ideas, and subsequently launching and managing a business.

3. More risk-taking activities could be encouraged through BETA complemented with topics and case studies on teaching students how they could take calculated risk.
4. Review the existing year one programs to explore opportunities to promoting Risk-taking, Commitment to the Work Contract and Independence & Self Confidence in students.

Limitation and direction for future research

Our research is subjected to limitations on generalizability as it was conducted for the first time with a limited number of students. While the study focused on outcomes of entrepreneurial competencies, there are opportunities to explore students' experiences on the module. Variables such as learning styles, and personality types may be considered, and the use of in-depth interviews or other qualitative methods may possibly point us towards a pool of richer insights and feedback on fostering a richer module and student learning experience.

A correlation study can further investigate and draw conclusions over the relationship between students' overall grades (or academic achievements) and their performance in the module. Future studies may focus on the causality of PEC variables. Other statistical methods that could establish causation can be deployed to help with the identification of any causal relationship across personal entrepreneurial competencies.

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FACILITATING INTERDISCIPLINARY LEARNING: PROJECT "U-TRAP REFILL AUTOMATOR" FOR THE DEVELOPMENT OF ENGINEERING STUDENTS' SKILLS

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Abstract

This paper describes an authentic interdisciplinary learning experience carried out at Hong Kong Institute of Vocational Education (IVE), a member institution of the Vocational Training Council, and relates to its effects in the development of engineering students' skills. The main goal of the real-world project entitled "U-trap Refill Automator" (thereafter named "the device") was to present students with an intellectually demanding challenge by working collaboratively with other disciplines, and thus integrating knowledge to solve the problems they were challenged with. Specifically, the learning and teaching was carefully curated from different engineering disciplines across the campuses. The three disciplines worked on the basis that their discipline was equal in importance to the project, and with the objective to reduce risk of the spread of virus from entering into units via drying out of U-trap. The Civil Engineering students focused on the building regulations and facilities standards in installation, the Computer and Electronic Engineering students focused on the sensors and Internet of Things (IoT) application and the Engineering Foundation students focused on the device enclosure. A phenomenographic methodological framework was used for the study. Qualitatively, the research highlighted a) awareness of differences, b) engaging differences and c) integration of differences that students experienced interdisciplinary learning. The results demonstrated that students were aware of the relevance of the project not only for their education process but also for the development of their skills. It revealed that the students involved in the project had been capable of identifying the specific skills to appreciate both the benefits and the challenges of working in interdisciplinary teams. The project received a positive reputation for its teaching excellence and substantial links with industry, featuring the importance of joint teaching teams and particular student characteristics (including level of motivation and maturity) that may be helpful in planning future interdisciplinary education experiences.

Keywords: *interdisciplinary learning; higher education; engineering students; nurturing skilled talent.*

Introduction

Drain outlets or U-traps serve to stop foul odour and unhygienic substances, including bacteria and viruses, in the drainage system from entering living areas. Defective or dried U-traps could negate this important function. Or even worse, cases of the COVID-19 pandemic have been developed in some of aged buildings due to suspected reasons of drying out of U-trap.

Fears surfaced that the new coronavirus could mimic the 2003 SARS outbreak by spreading through U-shaped traps in building drainage systems, collaboration across multiple perspectives enhances the potential for innovative solutions to the complex issues of our time. Rather than focusing exclusively on an existing engineering subfield such as Biomedical, Civil, Environmental, Electrical, Computer, or Mechanical Engineering, the interdisciplinary approach arose as a way to further knowledge production and problem-solving with broad flexibility and a student-centered focus.

Grounded on a solid foundation of Vocational and Professional Education and Training (VPET) with integrating knowledge and skills across multiple disciplines for meeting the challenges of complex, changing and competing workforces of the future, this interdisciplinary project was specifically designed with integrated skills and knowledge from relevant academic domains. With an aim to prepare our students for a future of dynamic change, the authentic learning experience engaged all the senses allowing students to create a meaningful, useful, shared outcome.

Background

According to the HKSAR Government, in order to prevent COVID-19, U-shaped water traps must be filled with water to prevent dried traps and thus make it possible for the disease to spread. For an instance, water must be poured into the U-traps of drain outlets at least once per week in residential flats to reduce the risk of virus spreading through drainage pipes. COVID-19 has sparked a rise in creative inventions to help people adjust to the new normal. In order to reduce the risk of coronavirus spreading from entering into the indoor areas through drainage pipes, the project of inventing a device that could assist residents in monitoring the water level in the U-trap while refilling water automatically when the water contained in the U-trap is insufficient. Different academic departments (i.e. Department of Construction of IVE (Tsing Yi), Department of Engineering of IVE (Sha Tin), and Foundation Engineering programme of IVE (Kwai Chung)) were engaged to maximize the benefits for engineering students. Students were asked to combine their creativity with technology in the enhanced design for the users, especially the elderly and the people with disabilities. In order to ensure that water is regularly filling into the u-traps, the “U-trap Refill Automator” was invented with the following functions as shown in Figure 1:

(a) Water level detection of the U-trap and automatically refill water to the desired level;
(b) Memory function to save the current or any water level as the desired water level with one press of the button;
(c) Timer mode enabling user to set schedule in refilling the U-trap daily, weekly or monthly, capable to fit to drain where water level cannot be detected by the sensor such as vertical drain;
(d) Alert notifications to users when the water level of the reservoir or the U-trap is low through Mobile Applications, Instant Messaging and Email; and
(e) Mobile App for desired water level configuration, sensor readings and remote control of the U-trap Refill Automator operation.

The site installation for tenants/owners from the Urban Renewal Authority (URA) had been started since November 2021. The first batch of production (2000 units) was completed and had been distributed to URA's tenants for free. Tenants of four rehousing buildings were benefited from the donation (660 units), including a) 12 Soy Street, b) Shun Sing Mansion, c) Bedford Tower, and d) Rich Building. Owners/tenants of two acquisition units were benefited from the donation (700 units), including a) Wing Kwong Street / Sung On Street, and b) Kai Tak road / Sa Po Road. The device was equipped with an ultrasonic sensor to detect the water level in U-traps. When the water level falls too low, the device’s injection valve will open and release water into pipes. A water seal is then formed to block any viruses from entering the home as shown in Figure 2. Furthermore, the modifications and the future applications of IoT were in line with the preliminary designs and the team built multiple prototypes with the added functionalities and attained multiple field tests at site with satisfactory results to explore the possibility to develop the device into next version to incorporate more sensors and Internet-of-Things functionalities.

Figure 1: By adding a new attachment to the original design, the upgraded device can be fitted to both floor and wall drains.

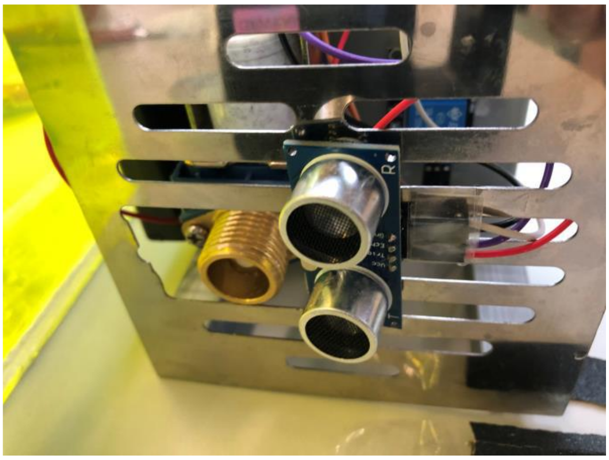

Figure 2: The “U-Trap Refill Automator” is able to sense when water level within U-trap in the pipes get too low, sending a signal to the device to inject water into the system.

Literature Reviews

Higher education faces the challenge of preparing future professionals to search for solutions that promote multidimensionality through collaboration and an interdisciplinary outlook to respond to society’s increasingly complex problems. To a certain extent, real-life engineering projects are in interdisciplinary nature that does not work in silos. As Ledford (2015) argues we must “bring people with different kinds of skills and expertise together. No one has everything that’s needed”. Without exception, engineers are expected to work with people with different disciplinary knowledge to solve real-world problems that are inherently complex. This is one of the reasons that interdisciplinary learning has

become a common pedagogical practice in engineering education (Hsu, 2015). A growing number of scientific papers have been published outlining university teaching projects and experiences based on an interdisciplinary approach (Klaassen, 2018; Power et al., 2019). For a sustainable development in the university context to enhance people lives and advance sustainable development, it is necessary to adopt an interdisciplinary approach in education (UNESCO, 2014).

In a review of the literature on the development of interdisciplinary thinking in higher education, Spelt et al. (2009) put forward the hypothesis that a positive relationship between certain conditions including a) students' motivation and maturity; b) the degree of interdisciplinarity; c) the collaboration among the teaching team; and d) the conditions of the interdisciplinary learning process. Additionally, the implementation of innovative processes and products is dependent on the development and execution of entrepreneurial strategies (Mars & Hoskinson, 2013). Adopting interdisciplinary approach can enrich the general educational experience that involves linking different disciplines together and creating faculty and student teams (Jones, 2010). Many studies (DeZure, 2010; Domik & Fischer, 2010; Fraser & Greenhalgh, 2001; Klein, 2008; Little & Hoel, 2011; Stentoft, 2017) have highlighted the need for learning, teaching, and education to stay close to the problems of the real world when designing interdisciplinary learning activities in higher education. Little & Hoel (2011) have also highlighted how participating in interdisciplinary teaching–learning groups encourages the adoption of a more interdisciplinary outlook, which goes beyond one's own discipline and acknowledges the contribution made by other disciplines to the resolution of the problem at hand. According to Woods (2007), all members of the group should participate actively and tackle real-world problems through experiences based on interdisciplinary collaboration with maximized interdisciplinary communication. Levy et al. (2017) also stress the importance for higher education to include more learning activities that designed to foster interdisciplinary thinking and collaboration. In this research, to enhance the quality of project implementation, the project incorporated suggestions from the literature in order to encourage cooperation and interdisciplinary learning.

Methodology

The study explored the different ways that engineering students experience interdisciplinary learning based on a phenomenographic methodological framework as depicted in Figure 3. Participated engineering students with various interdisciplinary learning experiences were interviewed using focus group discussion. The students concretely described their experiences and reflected meaning associated with those experiences. The results may offer insights into the design of curriculum and classroom interdisciplinary experiences in engineering education. In theoretical framework, phenomenography is related to a field of knowledge, which is the empirical study of the different ways in which people think of the world. Its aim is to discover the qualitatively different ways in which people experience, conceptualize, realize and understand various aspects of phenomena in the world around them (Bowden et al., 1992). In phenomenographic research, the researcher chooses to study how people experience a given phenomenon, not to study a given phenomenon.

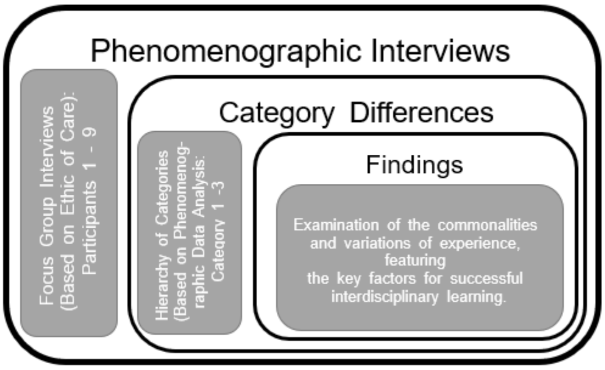

Figure 3. The phenomenographic methodological framework for project "U-trap Refill Automator".

Results and Discussion

Category Differences of Interdisciplinary Learning

Category 1: Awareness of Differences

Three groups of students based on their own disciplinary of studies were formed including programmes Higher Diploma in Civil Engineering, Higher Diploma in Computer and Electronic Engineering and Diploma of Foundation Studies - Engineering. Sub-groups of the students were requested to investigate the hygiene conditions in above-ground drainage systems in Hong Kong. To enhance students' interdisciplinary collaboration skills, students engaged in a series of knowledge sharing activities. These activities enabled the students to recognize and reconcile their disciplinary differences and biases, which arose the cognitive diversity of the team. To their surprise, they found that there were different general considerations from various sub-teams. Added to this, they identified pipework problems differently with comments that the toilets were often too narrow, and that many of the elderly and disabled people were simply too frail to do repeated tasks such as manually pouring water into the pipes. This led to the idea of building a device that would sense when water levels got too low in the U-pipes, in turn activating an electronic water injector to bring water levels back up to a safe level. Different concept designs were generated among the interdisciplinary team with a common goal to help reducing the risk of the virus spreading.

Category 2: Engaging Differences

Then, students were assigned to interdisciplinary teams to identify and prototype for a real-life problem. In order to build the device, Civil Engineering students admitted that the team had to refer to the knowledge of

civil engineering hydraulics, water supply and drainage system as well as building structures. At the same time, Computer and Electronic Engineering students were demanded to look at ways to make the device smarter by using the IoT technique or smartphone apps that can send reminders to add water to the pipes. Concurrently, Foundation Engineering students used their architecture-related computer drawing skills and 3D printing skills to get the installation off the ground by making the device more convenient and easier to use. Such authentic learning engaged all the senses of students to create a meaningful, useful, shared outcome. The project provided students in different sub-team to work together with meaningful and deep learning experiences and enhanced the student experience of real-world issues.

Category 3: Integration of Differences

Afterward, the project integrated and synthesized multiple knowledge from different disciplines to broaden students' learning experience and nurture their talents with interdisciplinary knowledge and independent thinking skills. Students from different engineering programmes had been actively engaged in the project providing assistance throughout the whole project life cycle. As such, students' learning experiences as well as their authentic exposure in engineering relevant applications for public value creation under the contemporary pandemic context had been enriched. Their problem-solving, critical thinking and collaboration skills, were also sharpened with a deeper understanding and greater retention of the subject knowledge.

Joint Teaching Teams

The students who were benefited from the interdisciplinary learning experience were lectured by professional teaching staff from different academic domains, and where necessary, by practitioners in chosen industries. Joint teaching teams were brought together with passionate and inspiring tutors from different disciplines to develop students' potential. In order to support collaboration and integration, the project was moderated by two leading supervisors namely Kelvin K.T. TO with an expertise in Mechatronics and Benson K.H. HUNG with an expertise in Civil Engineering. Kelvin made recommendations including but not limited to IoT applications, Printed Circuit Board (PCB) design and Bill of Material (BOM), message alert system, as well as computer and electronic issues for improvement. Benson made recommendations including but not limited to field tests and installation coordination, 3D printing and prototyping, as well as building regulations and facilities standards compliance. Students were supervised to further develop the device to a workable prototype with the added functions including timer, alarm and alert, with a view to enrich students' interdisciplinary learning experience and skills education.

In addition, one of the strategies to strengthen the promotion of VPET is to raise the research capability of the VPET institutions. Against this background, staff with the skills, opportunities and environment were engaged in cross-disciplinary research and research-led teaching in this project. The project not only increased the capability of council staff in applied researches, but also developed council staff's expertise in the specific study areas. The project intensified the research efforts in the council and provided innovative solutions to practical issues to help the community. This project also fostered innovation to cope with social challenges we faced in Hong Kong. As a result, it found that the degree of interdisciplinarity and collaboration among the members of the teaching team were at utmost importance for the successful implementation of interdisciplinary learning.

Particular Student Characteristics

As mentioned in the literature review, the hypothesis that a positive relationship between certain conditions can foster the development of interdisciplinary thinking in higher education held. In this research, a similar finding was also found in term of particular student characteristics (including level of motivation and maturity).

The project was consistent with the VTC's objectives to enrich students with meaningful and deep learning experiences and enhanced the student experience of real-world issues. Students shared that they had gained maximized practical knowledge through the project with a high level of motivation. Furthermore, a change was observed in student motivation, specifically in participants' desire to learning. In our research, it was observed that students were more success-oriented and felt less anxious about failure. These attributes reflected a great attitude-related aspects of intrinsic motivation.

Apart from level of motivation, maturity was also found to be significant after the intervention of interdisciplinary learning. A self-initiated approach to learning in specific technical areas ensured that students were being exposed to cutting edge technologies. By actively tackling real-world issues, students were found a greater retention of content knowledge and were better able to apply what they know to new situations.

Conclusions

Ensuring environmental hygiene is important to reduce the potential for COVID-19 virus contamination, especially in the home. The HKGovernment reminds citizens to maintain their drainage pipes properly by pouring about half a litre of water into U-traps weekly as a defence against the passage of viruses. It is a household task that is sometimes overlooked. As such, the project supervisors had led a team of students to develop an engineering innovation to help, namely U-trap Refill Automator.

This paper reported the "U-trap Refill Automator" project developed to promote interdisciplinary learning that combined students from the Civil Engineering, Computer and Electronic Engineering and Foundation Engineering programmes and related to its effects in the development of engineering students' skills. Specifically, the learning and teaching was carefully curated from

different engineering disciplines across the campuses. The three disciplines worked on the basis that their discipline was equal in importance to the project. The research highligthed a) awareness of differences, b) engaging differences and c) integration of differences that students experienced interdisciplinary learning. It revealed that the students involved in the project were aware of the relevance of the project not only for their education process but also for the development of their skills. The degree of interdisciplinarity among the teaching team as well as particular students' motivation and maturity were essential to develop students' interdisciplinary competencies in a more comprehensive way.

Worth mentioning, this project had a robust partnership with the industry in building students' competencies in technical education. URA adopted and provided the device freely to those occupied units in their acquired properties and rehousing blocks. The authority developed the students' prototype into a product with a reasonable scale of production for the said purpose. Moreover, the team was able to further modify the design with assistance from the authority which provided professional advice and residential units for conducting trials. The device has been progressed to the second-generation and there were newly installed IoT components that can provide status-check and push notifications on a mobile application. The current solution overcame one of its biggest challenges with a design that could fit floor and wall drains, two common drain outlet designs in Hong Kong buildings, of all shapes and sizes. The engineering team is now preparing to test the device in some older buildings as well as shopping malls. We hope the industry will take notice of the design and take it to the next level and roll it out to the mass market.

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Activities of Practical Implementation about Developing Identification System using Color 2-Dimensional Code

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Abstract

Brand products and trusted manufacturer items are threatened by imitations. If imitations are spread widely, brand value or reliability will be lower, hurting the company's economic interest. To avoid these damages, appropriate methods are needed to distinguish genuine products from imitations. To distinguish genuine products from imitations by examining material or the quality of the item, special identification skills are needed. There are attempts to support this by techniques using artificial intelligence. On the other hand, there is a method to determine authenticity by revealing the background of the item using embedded unique information on the item. This method cannot judge whether a product is an imitation or not by the item directly, rather it determines its authenticity by the existence of identified items or the wide-spread existence of that item. Focusing on the latter method, to determine its authenticity, ingenuity is needed to keep from generating unique information on the item, and a system is needed to judge its authenticity by background information that is related to unique information. As for the ingenuity to keep from generating unique information on the item, we designed a color 2-dimensional code with encryption information and transformation for colorizing. Also, we built a server to manage the decrypted background information and to determine authenticity by unique information. In addition, we determine the authenticity algorithm by background information related to unique information. We also developed a web application to read the code and to show the result of the authenticity using smartphones. About this agenda, we were consulted by one printing machine products company. We could make solutions using experts in each field of ciphering, information systems, and coding theory. By this activity of practical implementation, we could have an entrepreneurial view through co-operation with the company's engineers. In this paper, at first, we show the design of the color 2-dimensional code that includes encrypted unique information. Second, we show the server to manage background information and determine authenticity. Third, we show a web application for code reading for a smartphone that reads the color 2-dimensional code, requests authenticity to the server by the code, and shows the result of authenticity. As a result, we show examples of recognition of the color 2-dimensional code and determine authenticity.

Keywords: *Identification, Color 2-Dimensional Code, QR-Code, Practical implementation, Co-operation with Company*

Introduction

One printing machine products company consulted us concerning the control of imitations. Brand products and trusted manufacturer items are spread widely, so they want to control imitations. We considered the problem and realized that the solution needs some elements: security, information system, algorithm, etc. So, we struggled with the project from each position.

This project is collaborative research between Kosen teachers and a business institution. We collaborated twice a year. The Kosen teacher reported research progress, and the business institution person gave us opinions. Kosen teachers considered solutions based on their opinions. We followed this cycle recursively.

For controlling imitations, we designed a color 2-dimensional code to determine identity. Also, we built a code reader and decode system to validate the authenticity process (Yutaka FUJITA & Shoichi ITO & Yoshinori FUJISAWA, 2022).

In this paper, we present the solutions to imitation control. First, we present the background of the theme. Second, we present a color 2-dimensional code for determining identity. Third, we present the code reader to identify the color 2-dimensional code, and the decode system to decode and recognize identity. Fourth, we show the result of recognizing and authenticating the printed color 2-dimensional code. At last, we show the solution of collaborating with the business institution.

Background

Brand product manufacturers and trusted item makers have a problem with imitation and copied products. There are two methods of distinguishing genuine

products from imitations. One method is to distinguish genuine products from imitations by the quality or characteristic points of the item. However, this method needs special identification skills. Another method is to authenticate items by unique information that is implemented on the item. This method cannot find imitation from the item itself. It needs an authenticity system based on an item's information and background. We focused on the latter method, we attempted to design a color 2-dimensional code to implement unique information, develop a code reader, and build a system to decode and authenticate the code.

Regime

To attempt this project, we built a team of three members. They each represented the fields of coding theory, cryptographic theory, and information systems. We tried to make solutions for the theme.

This theme was presented by one printer product company. We had meetings twice a year for two years. In the meetings, we report the progress of the research and we got comments on the progress. Through the meetings, we rebuilt the solutions for the theme.

In the meeting, we focused on some points. One point is that anyone can check items without identification skills. So, we made a method to determine its authenticity by revealing the background of the item using embedded unique information.

Another point is the locations where people can check from. So, we built a system on the internet. Therefore, the system must be secure. From a security viewpoint, the decoding process is built on the server-side.

Color 2-dimensional Code

A color 2-dimensional code has 5-steps to creation. At first, an item's unique information is encrypted by AES. The input data is unique information about the item, mainly the serial numbers. 32 bytes of encrypted data are given by input data with a 128bit key.

Second, a QR code with encrypted data is created. Encrypted 32 bytes data and 2byte padding characters will be 34 bytes of QR code data. QR code, version 4(33×33), error-correct level H, will be created like Figure 1.

Third, we shuffle QR-code cells. If a QR-code is colorized by cell mask pattern by exclusive-OR operation, some mask pattern matched to QR-code function pattern area will change to a known color. It can be the vulnerability of the mask pattern generator algorithm (Yutaka FUJITA & Shoichi ITO & Yoshinori FUJISAWA, 2020). So, a shuffle is applied to the QR code before colorizing (Yutaka FUJITA & Shoichi ITO & Yoshinori FUJISAWA, 2021). As a shuffle algorithm, a discrete logarithm problem is applied. This algorithm is used to decide displacement from the initial position to the destination position. To displace in one dimension, the QR code is changed from a matrix to a line, and each row is connected to a linear configuration. Linear cell positions from 1 to 1089 are shuffled to another position by a discrete logarithm problem (Eq. (1)). In Eq. (1), a is any constant value, and p is a prime number and primitive element.

$$y = a^{M} \bmod p \tag{1}$$

Figure 1 QR code

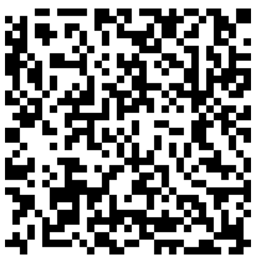


Figure 2 Shuffled Code

Initial positions are inputted as M, and destination positions are calculated as y. The p can be set at any number under the condition, not depending on the QR-code cell quantity. So, the shuffle is done on an extended range. Then, the shuffle needs to set the shuffled number to the 1-1089 range. If the destination position is over the range, the position is exchanged with another shuffle pair where the initial position is the destination position. The example is shown in Table 1 and Table 2. In the result, QR-code is shuffled like Figure 2.

Table 1 Shuffle Pattern (with over range)

M	1	2	3	⋯	78	⋯	1090
y	5	25	125	⋯	1090	⋯	787

Table 2 Shuffle Pattern(revised)

M	1	2	3	⋯	78	⋯	1090
y	5	25	125	⋯	787	⋯	1090

Fourth, the shuffled QR code is colorized with a color mask pattern. To recognize the code, it needs black light. The QR code is colorized. To colorize, 33×33 mask patterns are prepared. The mask pattern will be one of decode difficulty. Then the mask pattern is generated by a Mersenne Twister pseudo-random number. It generates random numbers with a 32-bit seed number. To set a range of 8-color from a random number, Mersenne

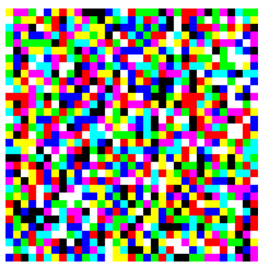


Figure 3 Color Mask Pattern

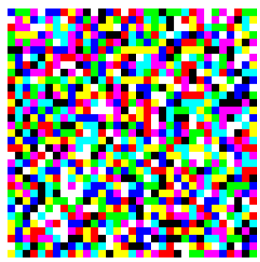


Figure 4 XORed QR code and Mask Pattern

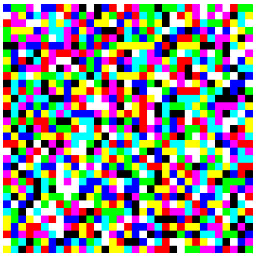


Figure 5 Colorized Data Area

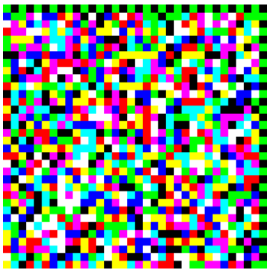


Figure 6 GK code

Twister pseudo-random number generator generates a double-precision number from 0 under 1, the number will be 8 multiplied, cast to 0-7 range number. It is assigned to 000,00F, …, FFF, 8 color number. The colors are mapped to matrix position: (0,0), (1,0), …, (32,0), (0,1), …, (32,32) (Figure 3). With the mask pattern, exclusive-OR operation is calculated by the shuffled QR-code and the mask pattern. It will be a data area of color 2-dimensional code (Figure 4).

Fifth, the function pattern is joined to colorize the data area(Figure 5). The function pattern is a black cell and a green cell, which are placed alternately on the upper side and right side. It will play a role in finding the code or measuring cell size. The result of the joint of function pattern and data area will be color 2-dimension code(Figure 6), we named it GK code. The “GK” means by function pattern color “G”reen and blac”K”.

Authentication System

For authenticity using the code, a code reader and decode and identification system are needed. The process flow is shown in Figure 7.

For security and convenience, the code read is implemented on the client-side, decode and identification are implemented on the server-side.

On the client-side, there are two choices, mobile phone application, and web application. With a mobile phone, it can be processed with good performance with the mobile phone hardware. However, both an Android application and an iPhone application are needed. With a mobile phone and web browser, no special applications are needed to be downloaded.

On the server-side, a decoding process is implemented. This is because decoding the code needs passwords and key phrases. If the decoding process is implemented on the client-side, passwords and key phrases are set by the client. Controlling will be hard. By decoding the process implemented on the server-side, security control is easier than if it is on the client-side.

An identification system is implemented on the internet. This is because authentication needs to access databases that are backgrounds relating to a unique number.

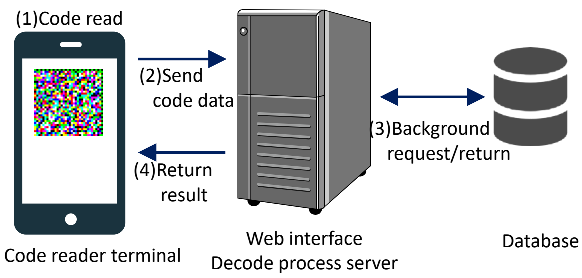


Figure 7 Process Flow

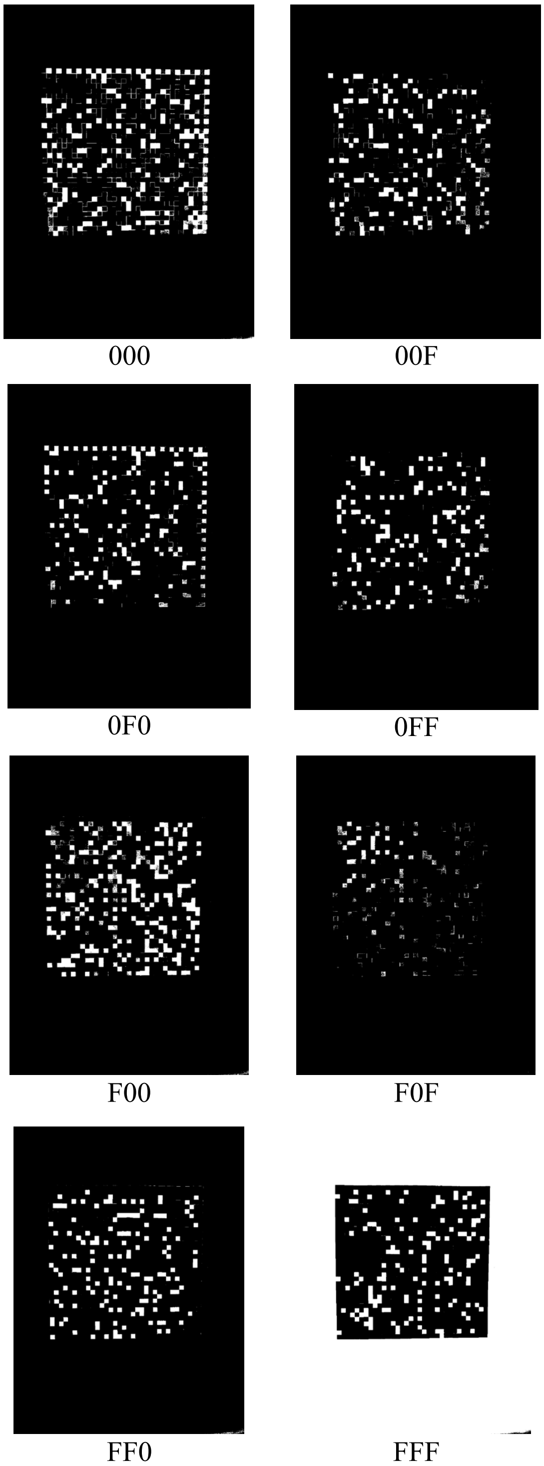


Figure 8 8-color Pickup Status

Code Reader

The reader is implemented as a web application on the web page by JavaScript and OpenCV library.

The reader uses a mobile phone camera through a web browser. The camera takes a photo, and a code recognition runs. At first, it extracts 8 colors pixel for each, 000, 00F, 0F0, …, FFF (Figure 8). For example, the 000 images are given by picking up pixels between (0,0,0) and (125,125,125). The (r, g, b) shows a pixel color value that 'r' means red color value, 'g' means green one, and 'b' means blue one. The 'r', 'g', and 'b' can have values between 0 and 255. Except for the background color, 7 colors extracted results are combined by logical OR (Figure 9). With the shape of the combined area (Figure 10), the code area in the original data (Figure 11) is transformed into a square (Figure 12). The square area is separated in a grid, 34×34, the color is picked up from each cell. For finding a green and black pattern, if the pattern doesn't place on top and right, it rotates the square. The color value of the 34×34 matrix will be sent to the server to decode and identify.

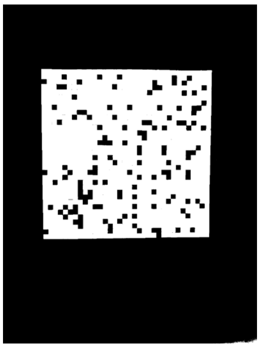


Figure 9 Aggregation of 7 colors

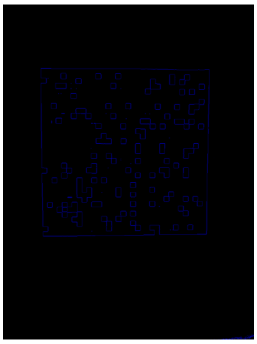


Figure 10 Shape of Aggregation

Figure 11 Taken Image

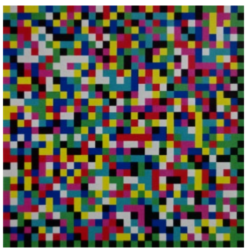


Figure 12 Stretched Square

Table 3 Database Table List

table	detail
serial	serial number, factory id, store id, decode id,
store	store code, store name
factory	factory code, factory name
access	serial number, date, device, result
decode	set name, AES key, mask seed, a, p
black	serial number

The code reader runs in a web browser. it can be installed as a smartphone application because the web application is built using PWA (Progressive Web Application).

Database

For decoding code and identification, decode information and background information are stored in the database.

The database has 6 tables: serial, store, factory, access, and decode, and black (Table 3). The serial table has item information, serial number, store information, factory information, and decode information. The decode information is one set of decoding for code. It includes AES password, mask pattern, shuffle setting constant number a and prime number p. Access log table and blacklist table are built. The access log table has authentication access information. These are useful for authentication.

Web Page

The code reader is developed as a web application. Using a camera device needs a `MediaDevices' interface. So, it requires a suitable web browser, especially chrome. For some mobile phones that do not meet the requirement, the web application provides an image input page that can accept a camera picture image.

Backoffice pages are built into the server. The pages provide management of background information, stores and factories information, serial number, decode information, access list, and blacklists.

The system is developed by the specification of Table 4.

Decode and Identification System

The decoding process receives a color cell-matrix sent by a code reader. Before the decoding process, decode sets(Table 5) are prepared by the database. Depending on each decode set, unveil mask pattern, apply shuffle pattern, QR-code decoding, AES decrypt. Making decisions on a suitable decode set, unique information is returned.

Depending on the unique information, authenticity is determined by referencing the blacklist list and the access list. To determine authenticity, we define the 3 categories of safe, caution, and warning (Table 6). The safe means

Table 4 System Specification

OS	FreeBSD 11.2-RELEASE-p14 amd64
Web	Apache/2.4.51
Language	PHP7.4.24
Database	MySQL 5.7

registration information is normal. The caution means the access log has abnormal status, for example, access to the unique item count is too high, and it looks suspicious. The warning means irregular background or blacklist item. For example, the unique information is not registered, the decoding set is different from what is registered, or blacklist is registered. The authenticity system will return code of the authenticity result.

Results

The safe result is shown in Figure 13. The caution result is shown in Figure 14. The warning is shown in Figure 15 - Figure 17.

Discussion

The following is discussion about the system. We created GK-code to avoid illegal code generating. To generate illegal code by brute-force needs the next steps.

For AES encrypt, AES-128-ECB has 128 bits key. It costs Eq(2) patterns by a brute-force attack.

$$2^{128} \cong 3.403 \times 10^{38} \tag{2}$$

For QR-code shuffling, the pair of constant value a and primary number p exist infinitely. But shuffle is applied in 1-1089 position number. For instance, 1st position transfer to one of 1089 positions, 2nd position transfer to one of 1088 positions, and so on. It will be continued to 1089 positions. In the result, it costs Eq(3) patterns by a brute-force attack.

Table 5 Decode Set Example

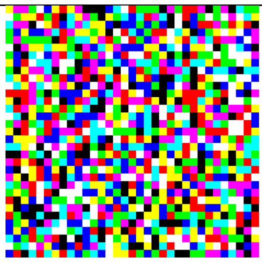
parameter	value example
set name	201809
mask/mask seed	 2345678901
AES key	0123456789abcdee
shuffle a	5
shuffle p	1093

Table 6 Authenticity Result and Code

result	code	detail
safe	100	no problem
caution	201	access overloaded
warning	301	number no registered
	302	blacklist registered
	303	decode set discord

Figure 13 Safe Result

Figure 14 Caution Result

Figure 15 Warning Result (no register)

Figure 16 Warning Result(blacklist)

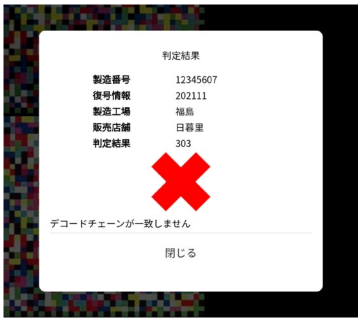


Figure 17 Warning Result (wrong decode set)

$$1089! \cong 1.969 \times 10^{2836} \quad (3)$$

For colorizing using color mask patterns, color mask patterns are generated by Mersenne Twister pseudo-random number generator. Mersenne Twister pseudo-random number generator generates with a 32 bits seed number. It costs Eq(4) patterns by a brute-force attack.

$$2^{32} \cong 4.294 \times 10^{9} \quad (4)$$

In the result, the complexity will be Eq(5).

$$2^{128} \times 1089! \times 2^{32} \cong 2.878 \times 10^{2884} \quad (5)$$

About the code reader, the code reader could pick up the cell color collectively. But sometimes it cannot pick up the correct color when the brightness is not suitable. It needs brightness control automatically. About the decoder system, each decoding step is correctly implemented.

About authentication, the authentication process could return a suitable result using background information. Now, caution results are returned when the access quantity is high. But using access places and any additional information can show wider caution results.

Regarding the co-operaion, the consideration and development are executed by the Kosen side researcher. Through communication with the business institution person, some activities are affected. One affected activity is the system structure of the reader and decoder. In the past, we developed smartphone applications as a reader and a decoder (Yutaka FUJITA & Shoichi ITO & Yoshinori FUJISAWA, 2019). Especially about the decoder, the decoding information is inputted into the application. So, decode information management was difficult. Even if the decoding information is managed by the server, decoding information is needed when decoding the code. The security management was difficult. Then, the decode process is implemented on the server-side, so the problem will be eliminated.

Conclusions

One printing machine products company consulted us concerning the control of imitations. We struggled with the problem with each specialized member of the business institution. GK-code was created, and the code decode and authentication system were built. Using the code and system, the system could return the result of authentication.

With this activity, we have attempted to assume actual use. By that point, the decoding process is implemented on the server-side. By taking the structure, management of decoding information is easy.

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Value-creating human resource development initiatives using traditional crafts that encompass STEAM education and measurement of their effectiveness

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Abstract.

With rapidly advancing technologies such as AI and IOT, social issues and their requisite solutions are diversifying. To solve such diversifying problems, engineers themselves need to take a value-creating approach that creates new values by fusing and combining technologies from different fields, rather than merely utilizing engineering knowledge and technologies.

"STEAM education" is expected to be one of these value-creating human resource development approaches. STEAM education adds an element of "art" to the existing STEM curriculum to provide students with a cross-disciplinary approach to their learning, ranging from science and mathematics to history, art, design, liberal arts, and other fields.

This method is expected to identify the essence of things and find a way to solve problems with new ideas by having perspectives from different fields. However, due to its diversity, how to introduce this method into the educational field has been considered a major issue.

In dealing with this issue, the National Institute of Technology (Kosen), Nara College developed the SHINAYAKA Engineer Education Program that encompass STEAM education. The program provides students with lectures and workshops, which are intended to develop not only their theory-based practical skills through engineering education at the college but also the ability (including team building or leadership) to enhance and integrate their "sensitivity" and "expressiveness" into products through the study of different fields.

This paper introduces the "ceramic workshop" conducted under the cooperation and guidance of Nara University of Education in this Education Program as an example of STEAM education in practice. The purpose of this workshop is to utilize the new value creation experience developed by the synergy between learning from the history and techniques of ceramics and engineering knowledge for the development of next-generation engineering leaders. Through this workshop, we summarize and analyze the educational effects obtained there and future issues from various perspectives.

Keywords: *STEAM education, traditional craft, value creation, interdisciplinary fusion, Sensitivity, Expressiveness*

1. Introduction

The industrial and social environment is transitioning worldwide into a period of structural transformation with the rapid progress and popularization of artificial intelligence (AI) and Internet of Things (IOT) technologies. Under such circumstances, we are expected to use our abilities to explore and solve various problems and create new values on our own for diversifying social issues and needs. This is also relevant to the current education system that is facing the need to change from traditional "knowledge base-expanding" education that emphasizes rote learning to retain knowledge and skills, to new "value-creating" education that highlights value creation ability, in other words, how to use knowledge and skills and the results that are produced.

Due to this situation, STEAM education has been attracting attention recently. "STEAM" is a term coined from the first letters of Science, Technology, Engineering, Arts (design and liberal arts), and Mathematics. STEAM education has its origin in STEM education (excluding the Arts) developed in the United States. After STEM education spread to other developed countries, the concept of Arts (design and liberal arts) was incorporated as the world environment changed, leading to "STEAM education" that includes not only science and engineering subjects, but also history, art, design, and liberal arts. STEAM education has been introduced worldwide as a cross-curricular education program to develop problem-solving skills and creativity through comprehensive learning, aiming at the identification and resolution of real-world issues.

In Japan, the Ministry of Education, Culture, Sports, Science and Technology released "Human Resource Development for Society 5.0 - Changes to Society,

Changes to Learning"[1] in June 2018 and recommended STEAM education as an approach that combines a wide range of knowledge and experience in a cross-curricular education program beyond the framework of science and liberal arts to cultivate individual problem-finding and -solving skills and value-creation ability. However, in Japan where each subject was taught independently and knowledge base-expanding education was the mainstream, the method of STEAM education that employs cross-curricular learning for value creation has not been established, nor have there been many examples seen in actual school settings.

In this paper, the SHINAYAKA Engineer Education Program of the National Institute of Technology, Nara College (hereafter referred to as Nara Kosen) is reported. The program was designed based on STEAM education, and as a practical example, we highlight its pottery workshop project. This was conducted with the cooperation and guidance of Nara University of Education to produce diverse engineers by providing students with a new value-creating experience through a fusion of learning from traditional pottery making and engineering findings. We also discuss the educational effects of the workshop and future challenges from multiple aspects.

2. Introduction of STEAM education in engineering education

In engineering terms, STEAM education can be interpreted as education to cultivate specialized knowledge in engineering, breakthrough knowledge for technological innovation and value creation from outside the field of engineering, and multidisciplinary knowledge derived from the convergence of these two different knowledge sources.

After due deliberation of the fusion of specialized, breakthrough, and multidisciplinary knowledge, Nara Kosen started the SHINAYAKA Engineer Education Program incorporating STEAM education in 2019. Specifically, the program focuses on areas less relevant to engineering, such as traditional culture, psychology, and design, and outside experts who usually do not belong in tech colleges including artists, designers, and psychologists give different types of lectures that can become a source of breakthrough knowledge. It also offers project-based learning (PBL) workshops with arts and sciences integrated as a place for practical application of multidisciplinary knowledge.

2.1 Significance of SHINAYAKA Education Program and its Curriculum Structure

Nara Kosen's SHINAYAKA Engineer Education Program aims to help students nurture sensitivity to create new values and expressiveness to embody these values, while developing the ability to adapt to diversity from multiple perspectives through learning in areas that differ from engineering. Another purpose of this program is to develop new engineering leaders who can bridge society, life, and technology so that people's lives can evolve with the experience of new values (creation of concepts, stories, or user experience related to technologies), which is enabled by combining adaptability to diversity fostered in this program with practical skills based on theoretical knowledge learnt in engineering education.

As shown in Figure 1, the curriculum of this program consists of three pillars.

(1) Lectures to cultivate sensitivity for perceiving things from different aspects

Increase student knowledge sources and encourage them to think about manufacturing from fresh perspectives by non-engineering lectures and practical training.

(2) Lectures to develop the ability to connect multiple perspectives

Develop the ability to create new value by connecting engineering knowledge and multiple perspectives cultivated in the "sensitivity" class.

(3) Lectures to cultivate expressiveness and convey value

Learn how to cultivate the expressiveness required to convey value to others in a tangible.

The curriculum based on these three pillars will be the driving force for students to discover, connect, and create new value.

In addition to theoretical and practical skills developed in engineering education at the tech college, this program consists of classroom lectures and workshops to refine sensitivity and expressiveness, the antithesis of engineering, through learning from different subjects and to cultivate the ability to integrate everything into a tangible form (including team building and leadership).

A compilation of classroom lectures is provided, inviting specialists and experts in their respective genres as lecturers to improve sensitivity and expressiveness. One class session lasts 120 minutes, with the first 90 minutes allocated to the lecture and the second 30 minutes to reviewing the day's lecture. In the workshop, students practice PBL over three days by creating works related to traditional culture or digital technology. The workshop is held in teams and team members are organized across grades and courses, regardless of age or the field of expertise. The aim of these team-based activities is to improve communication skills and the balance between independence and the collaborative spirit.

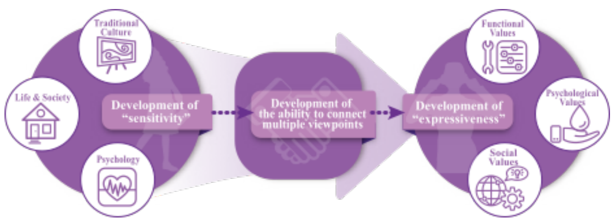

Figure 1 Curriculum structure

3. A practical example of a pottery workshop encompassing STEAM education

As an example encompassing STEAM education, the pottery workshop conducted in 2020 and 2021 is discussed in this section. The pottery workshop was held by Nara Kosen with the support and instruction of the second co-author, Professor Harayama from Nara University of Education.

3.1 Attainment Targets

The workshop was designed based on PBL for three targets from the standpoint of engineering.

The first is to facilitate engineering students to acquire consensus-building skills in a diverse environment with multidisciplinary students, with an understanding of the differences in critical thinking and viewpoints. The second is to directly experience traditional culture and cultivate sensitivity to perceive the intention underlying the craftwork process, following a series of steps from conception to design, review, and output. The third is to develop team-building skills during the process of working as a team, from defining the concept of the work according to the assigned theme to creating a piece of work within the time limit.

Another attainment target was set from the viewpoint of ceramics as manufacturing in this workshop. First, we discuss the following characteristics of the pottery industry whose pre-mass-production structure has been passed down to the present day, as seen from modern industrial manufacturing being studied by engineering students today.

In pottery making, the entire process is performed alone, from material procurement to production, such that the ceramic artist personally goes to mine clay from the mountains, shapes it, and then fires greenware in a kiln that he/she has built. Compared with mass production where the manufacturing process is highly divided, traditional pottery is more self-contained. This allows students to obtain a quick overview of the entire manufacturing process through pottery making practice.

No matter what the traditional craft is, many different tools are often needed to create a form. For example, smithing requires a hammer to strike metal plates to shape a form. Compared with other crafts, ceramics are unique in that the clay material is shaped with the hands to create a form so that its soft texture can be felt directly. Another characteristic of ceramics is that during the process of shaping and firing, the material changes its texture dramatically from soft clay to hard, lustrous ceramics.

As discussed above, ceramics have unique processes distinct from modern manufacturing, but every step is useful for understanding the essence of craftsmanship. Therefore, another target of this workshop was to promote students' learning about the characteristics of the pottery making process through practical training from conception to completion.

3.2 Workshop Class Design

The following details the class design for the pottery workshop in 2021 including the subject, theme, and time schedule.

(1) Pottery Technique

Considering the workshop's attainment targets indicated above and the three-day schedule, the following two pottery techniques were examined for application to this workshop.

One is press molding, by which students can create plates. As shown in Figure 2, this technique presses a clay plate onto a hemispherical plaster mold to form the shape of a vessel, and even those inexperienced in handling clay can make well-shaped vessels by this method. This technique is also characteristic for its ease of design, since patterns and designs can be expressed on the surface of the vessel using three different colors of clay.

Another is the creation of Raku tea bowls. Raku is a type of ceramics created using firing temperatures lower than those of normal ceramics. The author has previously studied pottery classes using this technique in " Study of self-building ceramic kiln for School and development ceramic art using this kiln: Aiming to make active learning on ceramic art subject in junior high school"[2] In general pottery classes and workshops, participants usually do not go as far as observing the actual firing process. However, the teaching method developed in this study uses a simplified kiln made from a drum, by which participants can observe their works being fired during the firing process right in front of them. Raku ware also allows students to enjoy interesting changes unique to ceramics by firing, such as random alterations of glaze due to the reduction effect.

We reviewed these two techniques and adopted the first design, making a plate using press molding. Compared with the second design that is more likely to be intuitive, the first design seemed more appropriate for the workshop because it allowed participants to work systematically and also afforded other components such as group work and product planning. After reviewing the workshop schedule in detail, we decided to make cups using the slab building technique that rolls plate-shaped clay into a cylindrical form as shown in Figure 3, in addition to making plates by press molding.

Figure 2 Press molding technique

Figure 3 Slab building technique

(2) Theme Setting

This workshop was conducted using a PBL approach. With the intention of encouraging students to think about changes and issues in the social environment due to the recent COVID-19 crisis, the theme for pottery production was: “Let’s have tea together after the pandemic is over.” This theme was chosen at a time when COVID-19 was prevalent and students stopped eating out with their friends, envisioning a scenario in which all group members could gather for tea (or dinner) in a happy, refreshed mood after the end of the COVID-19 pandemic.

Students usually work individually to create a piece of work in art classes. However, a group work component was added to this workshop to cultivate consensus-building and team-building skills as indicated in the attainment targets. Participants were divided into teams regardless of grade level or course. Basically, all works were created individually, but as a condition for the task, each team was required to produce a complete set of vessels with the same design concept and motif consistent with the theme. The primary focus of this was to have team members share the experience through the pottery making process.

(3) Time Schedule

Table 1 shows the three-day workshop schedule.

On Day 1, lectures on ceramic art and a conceptual work were mainly held. A work production on Day 2 and a presentation of the completed work on Day 3.

Days 1 and 2 were conducted consecutively. There was about a one-week interval between Day 2 and Day 3 to allow for drying before biscuit firing, glazing, and glost firing.

The students who study engineering tend to have less interest in the traditional culture such as ceramic art. Therefore, to stimulate interest in ceramics among the participants the prior assignment to make a presentation on their favorite vessels was provided.

Table 1 Time Schedule of workshop

Prior Assignment		To make a presentation on their favorite vessels	Individual work
Day 1	AM	Slide lecture on the basic knowledge of ceramics	Lecture
		Presentation of prior assignment: My favorite vessel	Presentation
	PM	Technical instructions, slide lecture on vessel desi	Lecture
		Slide lecture on how to determine the concept	Lecture
		Setting of design theme	Group work
		Setting of design theme and making draft design	Individual work
		Presentation of design theme	Presentation
Day 2	AM	Pottery making (plate)	Individual work
	PM	Pottery making (cup)	Individual work
Day 3	AM	Unloading the kiln	Group work
		Slide lecture on firing	Lecture
		Preparation of presentation sheets	Group/Individual
	PM	Preparation of presentation sheets (continued)	Group/Individual
		Presentation and feedback	Presentation

3.3 Workshop Method

(1) Workshop Day 1

As a starter, a slide lecture on the basic knowledge of ceramics was provided on Day 1. The basics of traditional ceramics were shared in this slide lecture, including ceramic producing areas across Japan and their characteristics, difference in materials used to make pottery and porcelain, difference in firing kilns, and historical transitions. The latter half of the lecture was used to introduce a variety of daily products made from ceramic materials and ceramic artworks from the past to the modern age, encouraging students' awareness of the breadth of ceramic expression.

Following a theoretical understanding of ceramics, each participant gave a presentation on their favorite vessels, and students shared an objective perspective on their interest in ceramic art.

In the next slide lecture, instructions were given on how to make pottery works. Participants were provided with the printouts of slides as handouts before the slide lecture and instructed to use them as a reference for work on Day 2. The technical explanation was relatively simple but each step of the process was precisely detailed, so the participants listened attentively, making notes on the printouts.

Then, as concept work, a slide lecture was presented on how to formulate a design concept for the work. For the concept work, the lecturer explained that concept creation should be based on 5W1H (when, where, who, what, why, and how), as the fundamental factor for sparking ideas from experience. Each team brainstormed the given theme and freely generated ideas, working together to put these ideas into one design concept and motif.

Subsequent to the concept work, each student drew draft designs based on the design concept and motif decided in the group. Concepts drafted by each group for the given theme included “tour around Japan” and “a vessel for outdoor tea ceremony at picnic sites.”

At the end of Day 1, to familiarize themselves with clay handling, students actually worked for about an hour on elementary modeling assignments with clay with

several tasks such as rounding clay into a beautiful sphere or making a hole in ball-shaped clay to form it into a vessel shape.

(2) Workshop Day 2

Day 2 of the workshop was devoted to plate making in the morning by press molding, and in the afternoon, cup making by slab building. Thanks to the lectures on the previous day, it was impressive to see them thinking hard and working independently, referring to the printout distributed on the previous day. Despite working for as long as six hours straight from the morning through the afternoon with a lunch break in between, participants appeared to be concentrating on their work.

(3) Workshop Day 3

During Day 2 and Day 3, greenware was biscuit-fired, glazed, and glost-fired. To ensure that the works could be taken out of the glost kiln just in time for Day 3 of the workshop, glost firing was started two days before Day 3 and unloaded on the morning of the workshop with participants. When the participants saw their works—firing had just finished and they were still warm—come out of the kiln, their excitement was palpable.

Since students could not see the actual process of biscuit-fired, they were given a slide lecture explaining the process followed during Days 2 and 3 and to understand a series of processes.

The students then took photographs of the work using prepared background paper for photography and other supplies. Cutlery such as chopsticks and spoons, and confectionery were prepared for the photoshoots so that each participant could create original layouts. And, the created a presentation sheet.

Finally, the workshop was reviewed with a presentation using the prepared sheet and feedback.

Figure 4 shows one of the group works by the students. The design theme is "tour around Japan", which reflected their desire for travelling under the the circumstances of Covid-9. By putting map of Japan and specialities of the various regions as motifs, students aimed to develop imagination of the users and to make them enjoy as if they were travelling.

As can be seen from this example, our program provides different point of view from the different fields, in order for students to find the solutions to the problems through their work. In these respects, this program and STEAM education share common goals, as both aims to develop problem-solving skills, cultivate capacity and ability of value-creation.

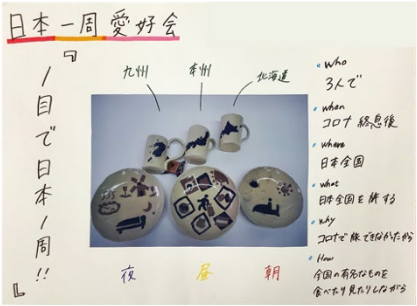

Figure 4 Work with design theme “tour around Japan”

4. Results and Discussion

The workshop was then discussed to assess its effectiveness and challenges.

A total of 25 students from different grades and courses attended the pottery workshop in 2020 and 2021. The participants were asked to complete a questionnaire including the following 3 questions after the three-day workshop. Blow is a content of each question and its result. (Number of valid answer : 21)

(1) Question 1 : Level of satisfaction with the workshop

Question 1 is to check students’ satisfaction with the whole program. As a result shown in Table 2, all participants reported that the content was as good as or better than expected.

Table 2 Students’ satisfaction level

Level	Number	Ratio
They exceeded my expectations.	16	76.19%
They were what I expected.	5	23.81%
They did not reach my expectations.	0	0%
They were disappointing.	0	0%

(2) Question 2 : One’s own perception of improvement of abilities throughout the workshop

Question 2 is to check what abilities participants felt had improved in themselves (multiple responses allowed). As shown in the questionnaire results in Figure 5, over 80% of students reported that they had increased their creativity. Over 60% of students had felt the increase of expressiveness. Also, nearly 30% of students reported that they had increased their critical thinking skills from multiple perspectives and became able to see things in a different way than they had before, which suggests that the SHINAYAKA program had a certain level of positive impact on the development and improvement of student abilities.

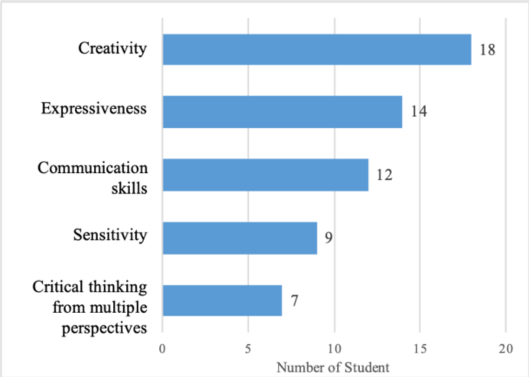

Figure 5 Abilities that students feel have improved since the workshop

(3) Question 3 : Overall impression

Participants' impression from the workshop was confirmed in Question 3.

As shown in Table 3, there were many positive feedback. It means that the workshop was effective for student learning.

Table 3 Students' feedback

Feedback
I was able to create a work of design that I would not otherwise have come up with on my own through the group designing process.
I learned how to find new concepts and how to share and develop ideas with others in making pottery and sharing ideas with group members
I had a good experience because it was mainly based on group work and I was able to learn leadership and collaboration skills during the process of finalizing the idea and communicating extensively
Even I, who have a poor artistic sense, have managed to develop my design skills.

5. Conclusions

This paper described an example of STEAM education implemented as part of a pottery workshop in the SHINAYAKA Engineer Education Program, and analyzed the effect of the education program based on the review and questionnaire survey results collected from participants about the lectures.

As a result of the analysis of the workshop that introduced STEAM into engineering education, we conclude that including PBL components in the traditional craft workshop and encouraging participants to output solutions to assignments with the five senses would be an effective educational approach for facing and dealing with social issues from a different angle to that of engineering. This contributes to the development of abilities to explore and solve diversified social issues and needs, and nurture the potential to create new values on their own, in a manner consistent with the essential purpose of STEAM education.

The target of the pottery workshop was making plates and cups by press molding and slab building techniques, respectively. From a technical perspective, these craftwork techniques may be slightly time-consuming, but as long as participants follow the steps carefully, no major failures are likely to occur. We found that this subject was appropriate for engineering students. Moreover, participants seemed to be deeply impressed and enjoy the new experience of pottery making in the workshop, as they occasionally cheered in delight when they handled clay, finished shaping and glazing, and took their work out of the kiln. The experience could be improved further if, in addition to making pottery for pure enjoyment, participants reconfirmed their individual skills through the experience of craft work that is completely different from their own specialized areas.

Further investigation is required on how sensitivity and expressiveness are cultivated by learning different fields of study in the SHINAYAKA engineer education program, including the pottery workshop, and what effects STEAM education will have on critical thinking from multiple perspectives. In addition, it is necessary to identify the methods that should be used to introduce STEAM education into engineering education, with continued implementation of the program in the future.

Acknowledgements

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EFFECTIVENESS OF INTERNSHIPS IN ENCOURAGING ENTREPRENEURSHIP

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Abstract

Internships are widely deemed to be useful in facilitating entry into the workforce. Much research has been done into this positive link, such as the recent study by the International Labour Office, which went as far as to identify the specific features of internships that lead to stable employment (ILO, 2018). This paper considers whether the features of the internship experience, which was originally designed to provide "a smoother transition into the workforce (SkillsFuture, 2022)" are just as effective in encouraging entrepreneurship among interns.

There is increasing recognition of the role that entrepreneurs play in economic growth and the need for schools to cultivate entrepreneurship in students (OECD, 2001). Internships, which occupy a substantial portion of the curriculum, are a useful platform and many educational institutions now offer internships that incorporate entrepreneurial learning. However, the literature review indicates that such efforts yielded mixed results. Chillas, Galloway and Marks (2014)'s study of internships' ability to foster entrepreneurship in the IT sector in Scotland found that while internships helped companies recruit fresh talent, the interns themselves had "little… ambitions to create new firms." An earlier study by Liew (2008) of Malaysian interns noted that attaching interns to entrepreneurs can provide inspiration but the entrepreneurial learning is limited because the interns "do little things in the office" and did not gain actual experience in running a business.

This paper seeks to contribute to the existing research by studying the experience of interns from Temasek Polytechnic's School of Engineering to evaluate the extent to which the interns were inclined to pursue entrepreneurial paths. The method used is to refer to post-internship surveys to gauge the interns' entrepreneurial interest. A cluster analysis is then conducted to identify similar traits among the entrepreneurial-minded interns. Results will show that entrepreneurial-minded interns are in the minority but do possess some common traits and that the current internship experience provides them with adequate support for their future careers.

Keywords: Internship, Curriculum, Employment, Engineering, Entrepreneurship, Higher Education

Introduction

Internships expose students to a particular job or industry with the intention to prepare them for full-time employment. SkillsFuture- the Singapore government agency tasked with equipping Singaporeans with employable skills throughout their careers- explains that internships should provide "a smoother transition into the workforce (2022)." The United Nation's International Labour Office, in its 2018 study, identified the types of internships that would lead to better employment outcomes (ILO, 2018). Institutes of Higher Learning also share this sentiment, with the National University of Singapore (2022) describing internships as "an important aspect of career preparation." Internships are an increasingly common feature of higher education for students to obtain industrial experience and, according to the Oxford University Careers Service (2022), "valuable transferable experience for (their) CVs."

Yet, while employability- which internships seek to promote- is a necessary condition for a country's economic well-being, it is not the only one. The United Nations Conference on Trade and Development's 2004 report noted that entrepreneurship, which is a "source of innovation and change," is an important driver of economic competitiveness in the modern economy that experiences rapid technological change (UNCTAD, 2004). More recently, the Asian Development Bank published a Technical Assistance Report that called for developing countries to nurture digital entrepreneurship to make their economies more resilient post-pandemic (ADB, 2021). Given this reality, this paper considers whether internships, which occupy a substantial portion of the curriculum, can also be effective in promoting and supporting entrepreneurship among students and whether such students have any common traits.

Literature Review

The advantage that internships have over a classroom education in entrepreneurship is the experience of operating in an entrepreneurial environment and/or mentorship by an industry practitioner that is the entrepreneur himself. However, the literature review of the link between internships and entrepreneurship yielded mixed results. Liew (2008)'s focus group study noted that interns could be inspired by their entrepreneurial mentors but the learning is limited as the interns "do little things in the office" and might not gain actual experience in running a business. Chillas, Galloway and Marks (2014)'s study of internships' ability to foster entrepreneurship in the IT sector in Scotland found that while internships helped companies recruit fresh talent, the interns themselves had "little… ambitions to create new firms." In contrast, Higgins, Shroeter and Wright (2016)'s survey of 132 agribusiness students in California noted that entrepreneurial mentors during internships can indeed inspire entrepreneurship. The survey also identified common traits among their more entrepreneurial-minded students such as being male and having parents in the business. More recently, Jahan and Jahan (2019)'s study of university interns in Bangladesh concluded that internships can both encourage and train students to become entrepreneurs.

This paper seeks to contribute to the existing literature in two ways. First, by measuring the extent of entrepreneurial interest in a larger sample size of the 549 students from Temasek Polytechnic's School of Engineering who just completed their internships and identify common characteristics among the students who indicated interest in starting their own business ventures. Second, this paper will examine the extent to which the internships prepared them for their chosen career path.

Context of the Case Study

Every semester, third-year students from Temasek Polytechnic's School of Engineering undertake a mandatory internship lasting 16-20 weeks. This internship is part of the curriculum and is worth 12 credit units. Passing the internship is a requirement for graduation. This paper uses the recent April 2022 semester students as a case study. These 549 students completed their internships during the period April to August 2022. The students came from one of the diverse diploma courses offered in the school listed below.

Table 1: Number of student interns across the various diploma courses in the School of Engineering.

Diploma Courses	# Interns
Aerospace Engineering (AEG)	37
Aerospace Electronics (AEL)	52
Aviation Management (AMS)	59
Biomedical Engineering (BME)	49
Business Process Engineering (BZE)	71
Computer Engineering (CEN)	51
Clean Energy (CER)	5
Electronics (ELN)	64
Green Building & Services (GBS)	36
Integrated Facility Management (IFM)	62
Mechatronics (MTN)	63
Total	549

Method of Evaluation

At the end of the internship, students are required to complete a mandatory online electronic survey. All 549 students responded. The survey consists of 37 questions that measure the nature and quality of the internship experience as well as learning outcomes. The response format to the questions is a mix of 'Yes/No/Maybe,' multiple choice, 5-point scales and free text.

One of the survey questions- Qn. 21- asks about students' plans after graduation and, more specifically, the likelihood of starting their own business venture. To respond to this question, students used a 5-point scale ranging from 'Very Unlikely' to 'Very Likely.' Students who responded 'Likely' and 'Very Likely' were identified as those with entrepreneurial interest. These students were grouped according to internship demographic clusters to identify commonalities. This paper then cross-referenced these students' responses to other relevant questions in the survey to examine the extent to which the internships prepared them for their chosen career path.

Results and Discussion

17.5% or 96 of the 549 students responded that they were 'likely' or 'very likely' to start a business venture. The 96 students can be grouped according to the following internship demographic clusters in Table 2.

Table 2: Demographic clusters of the 96 entrepreneurial-minded students who indicated interest in starting a business venture.

Gender	# Interns	% of total student popn. - gender
Male	86	19.4%
Female	10	9.4%
Diploma Course	# Interns	% of total students in the diploma course
AEG	8	21.6%
AEL	7	13.5%
AMS	6	10.2%
BME	7	14.3%
BZE	21	29.6%
CEN	12	23.5%
CER	0	0.0%

ELN	13	20.3%
GBS	8	22.2%
IFM	7	11.3%
MTN	7	11.1%
Organisation Type	# Interns	As a % of entrepreneurial-minded students
MNC	40	41.7%
SME	40	41.7%
Start-Up	5	5.2%
Government Agency	11	11.5%

More male than female students indicated an interest in entrepreneurship. This is not entirely surprising given that there are more male students studying engineering. A more useful comparison would be against the total student population in the school of that gender, in which case male interest in entrepreneurship still outweighed female by 2 to 1, 19.4% v. 9.4%. In terms of the course of study, the highest percentage of would-be entrepreneurs were found in the Business Process Engineering (29.6%), Computer Engineering (23.5%) and Green Building & Services (22.2%) courses. These courses are considered to teach 'softer' engineering skills and the eponymous top course also teaches business skills and, hence, the results might not be surprising. The organisation type did not influence entrepreneurial career choices with both MNC and SMEs having an equal number of entrepreneurial-minded interns. Moreover, the 5 students who interned in start-ups and expressed entrepreneurial interest are in the minority. The vast majority of students who interned in start-ups that semester (76%) had no interest in starting a business. This would support Liew (2008)'s finding that interning in small companies does not necessarily inspire students to run their own business.

Table 3: Frequency count of the 96 entrepreneurial-minded students assigned to respective companies

# companies with entrepreneurial-minded interns	# interns at each such company	total # entrepreneurial-minded interns
2	4	8
5	3	15
11	2	22
51	1	51
		96

This paper also reviewed the companies that the students interned at. The names of the companies are kept confidential. Table 3 shows that the count of interns at a single company ranged from 1 to 4. The majority of companies hosted only 1 intern. Hence, no single company stood out in terms of hosting a significant number of entrepreneurial-minded interns.

This paper now considers the extent to which the internship prepared students for entrepreneurial careers based on the 96 students' responses to 4 questions that are illustrated in Figures 1-4. The students responded on a scale of 1-5, ranging from 1 being 'Not at all' to 5 being 'A great deal.' This paper takes responses of 4 and 5 as positive and juxtaposes them against the 96 entrepreneurial-minded students who responded 'Likely' and 'Highly likely' to Qn 21.

Figure 1: Extent to which students were provided with adequate guidance during the internship

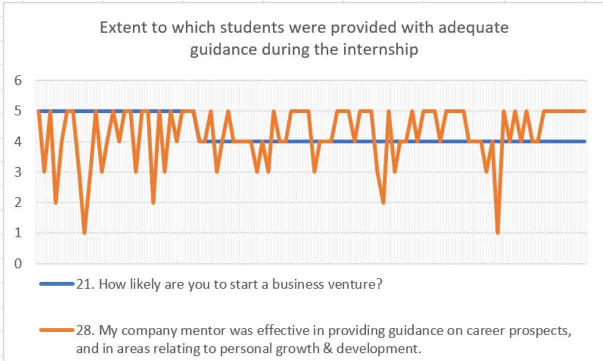


Figure 2: Extent to which the internship developed life skills

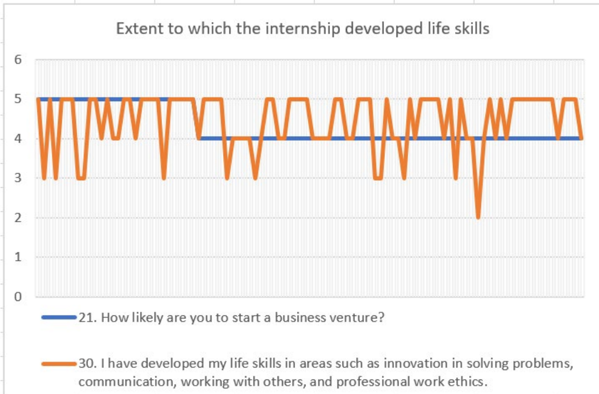


Figure 3: Extent to which the internship prepared students for the workforce

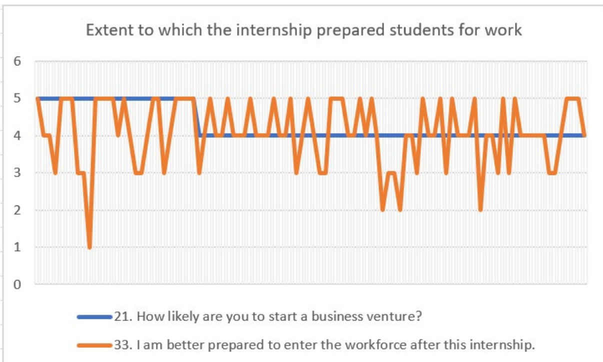
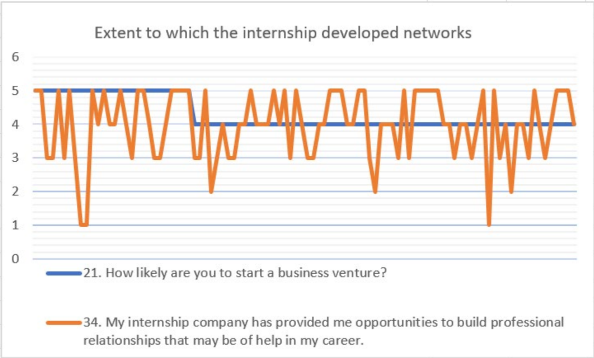


Figure 4: Extent to which the internship provided students with networking opportunities



From Figure 1, a sizeable majority of 78 (81.3%) out of the 96 students indicated that they received adequate guidance from their internships mentors on career and personal growth. An even larger majority of 84 students (87.5%) indicated, in Figure 2, that they developed life skills during the internship in areas like innovation, problem-solving and communiation, which are essential for budding entrepreneurs. From Figure 3, it is revealed that 74 students (77%) responded that the internship prepared them for the workforce. Finally, Figure 4, which refers to the development of professional networking skills - also essential for entrepreneurs- shows that 67 students (69.8%) responded positively. Hence, the results of all 4 clusters show that the overall internship experience benefited the entrepreneurial-minded students. Yet, interestingly, when this same group of students was also asked whether they 'acquired or deepened skills that are related to (their) area of study,' only 61 (63.5%) responded positively. This meant that a sizeable minority saw no link between their internship training and their classroom curriculum. This might suggest that the students' course of study was not a consideration when determining the field of the business ventures they hope to start.

Conclusion

Internships are not particularly effective in encouraging entrepreneurship as seen by the low number of students who responded in the survey. This paper studied their internship experience to find commonalities that might be built upon to encourage entrepreneurship among more students. This paper found that entrepreneurial-minded students tend to be male and come from courses of study that teach business and/or 'softer' engineering skills. The size and type of internship company has no impact. Nor was any specific company particulary effective in encouraging entrepreneuriship. This suggests that entrepreneurial ambitions might have been sewn before the internship. To encourage entrepreneurial mindsets, the school can consider providing pre-internship orientation in business or similar subjects to all students. Finally, from this study, it seems that the role of internships would not be to encourage but to prepare already entrepreneurial-minded students to embark on their buusiness own ventures. Internships were found to have performed this role well.

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