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Research Reports

Juha Kontio, Meiju Keinänen,
Tarja Åberg & Elina Asukas (eds.)

ISATE 2021:
Conference proceedings

August 17th–20th, Turku, Finland

TURKU AMK
TURKU UNIVERSITY OF
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August 17th–20th, Turku, Finland – part 1

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Editorial

The event International Symposium on Advances in Technology Education (ISATE) started in 2007 as international academic exchange between ten engineering colleges (known as Kosen in Japan) in the Kyushu and Okinawa districts of Japan, and three polytechnics in Singapore. It aimed to enhance the quality of Engineering Education in each participating institution. In 2010, all the other Kosen institutions of Japan joined the symposium under the initiative of the National Institute of Technology (NIT). In 2011, two more polytechnics from Singapore joined this international exchange effort as organizers. In 2013, Nagaoka University of Technology and Toyohashi University of Technology also joined the symposium. Hong Kong Institute of Vocational Education (IVE) of Vocational Training Council (VTC) officially joined to become one of the ISATE organizers in 2017. Turku University of Applied sciences has been active in the ISATE network since 2013 and was selected to host the ISATE 2020 conference. ISATE 2020 would have been the first time when ISATE is organized outside Asia. However, Due to the COVID-19 pandemic, the ISATE 2020 conference was postponed to 2021 and, renamed as ISATE 2021 and it turned out to be a fully online conference hosted from Turku, Finland. The conference took place on August 17– August 20, 2021.

ISATE 2021 was the 14th ISATE conference, and the main theme of the conference was Educating Future Innovators. There were the following seven subthemes:

- Active Learning Environments
- Collaboration of Educational Institutions and Industry
- Continuous Improvement and Quality Enhancement
- Pedagogy for Future Professionals
- Sustainable Development in Education
- Health Technology and Medical Engineering
- Functional Engineering Materials

There were four contribution categories: keynotes, invited presentations, full papers and workshops and several different session categories such as traditional presentations and pre-recorded videos. There were three keynote presentations:

- A journey through tomorrow's landscape of higher engineering education,
  Dr. Aldert Kamp, Co-director of CDIO initiative, the Netherlands
- Kosen now,
  Dr. Mitsuteru INOUE, Ph.D., Senior Director, National Institute of Technology, Headquarters, Japan
- Online education, assessment, and future after COVID-19,
  Marjo Joshi, Chief Advisor, Turku University of Applied Sciences, Finland

The tradition of ISATE is to have invited presentations from the key collaborators during the conference. At ISATE 2021 there were six invited presentations:

- Kosen Gear 5.0 to foster leading engineers for society
  5.0, Dr. Motomu Takeshige, NIT Suzuka College, Japan
- NYP experience in developing I&E competencies in learners
  Mr. Yang Tien, Nanyang Polytechnic, Singapore
- Pedagogy for future professionals
  Dr. Meiju Keinänen, Turku University of Applied Sciences, Finland
- Collaboration between Educational Institutions and Industry
  Dr Daniel YAN, Vocational Training Council, Hong Kong
- Preparing Students for the Future of Work,
  Dr. Boon Seong WOO, Temasek Polytechnic, Singapore
- AR/VR technology in education,
  Dr. Mika Luimula, Turku University of Applied Sciences, Finland

This publication contains the 141 accepted full papers that were presented at the conference. In addition, there are descriptions of 8 workshops. We hope that these contributions are valuable in developing your own research and teaching and learning in your higher education institute.

Turku, October 5, 2021

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Active Learning Environments

Teaching Mathematics in/and English as a CLIL Approach to Engaging Technology Students

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Abstract

Employing mathematics and online learning technologies in a CLIL approach to English language teaching can improve student engagement. Also, this approach, when combined with flipped classroom techniques, fosters student motivation by providing opportunities for active, apparently relevant engagement with the second language. Results from a 2017 survey of Tokuyama Kosen students indicate that even though students often receive the message that English is necessary, they do not perceive a connection between English and their daily experiences anymore than they perceive how this foreign language might have any relevance outside of school. Due to their existing familiarity with, and a certain degree of mastery over, the mathematics to be covered in such a course (which will be aimed at a level lower than their actual mathematics level), engaging with this subject *in/and* English could provide students a sense of relevance for the English being learned and increased confidence when utilizing a foreign language. This confidence can further be strengthened by having the students take the role of teachers—by flipping the classroom—and helping other students and the teacher solve mathematical problems. In this flipped classroom, students take active responsibility for using English in the classroom and for studying relevant online learning modules on Khan Academy prior to class. The process of earning points and badges in these online learning modules—a popular feature of Khan Academy—"games" the classroom environment, providing additional motivation via competition between students and groups. Final course evaluation can be based on the student's mastery of the target materials, in-class participation, and points awarded for online content. Correctness of English need not be considered for evaluation; the main point of this course is to engage students in English whenever possible, in a way the students themselves observe as being relevant to their daily (school) life and to their life after graduation.

Keywords: *CLIL, English, Mathematics, flipped classroom, online resources, Khan Academy, student motivations*

Introduction

Traditional reservation among Japanese students to participate in classroom discussions combined with a conceptual disconnect between English and the daily lives of our Japanese students create an environment at the National Institute of Technology (Kosen) where students are reluctant to contribute to classroom. Contributing to this reluctance is the stereotype that "tech people" are poor at communication and even poorer, thereby, at speaking in a second language. This stereotype is reified by images in popular media and social interactions:

> The field of engineering in particular has the reputation of harbouring people who do not like foreign languages, in fact, people who do not like to talk much at all. The image of the geek who will potter for endless hours in contented isolation, who is absolutely fascinated by the intricacies of technological problems and their solutions but averse to talking about them to the rest of the world, represents a powerful stereotype. All stereotypes do have some foundation in reality and so does this, but – like all stereotypes – it also draws its force from being habitually recreated by the discourses of society. These discourses can be personal conversations, media products, and movie characters or, indeed, the content of curricula designed for engineering and technology education. (Dalton-Puffer, Hüttner, Schindelegger, and Smit, 2009)

On top of this "introverted techno-geek" image, Japanese technology students are further burdened by the common and often-broadcast belief that Japanese people are somehow "not good" at English.

How to overcome this perceived, and often self-determined, "weakness" in our students? Focus English classes on subjects with which the students already familiar yet which also meet their current learning goals. In effect, teach science-oriented subjects in English in a manner in which students perceive the English as a means to learning, not simply as the subject being learnt. This method can best be recognized by the term "Content and Language Integrated Learning" or "CLIL."

What is CLIL? A Working Definition

There is no single definition of the group of techniques and practices that come under the term CLIL. However, most researchers and practitioners agree that in effective CLIL instruction task as the priority, with language as vehicle for accomplishing the task: "Language is not assessed as a separate entity, but as the vehicle for the accomplishment of production-based objectives (observable as tasks)" (Ball, 2015). In this, CLIL and TBL share a common methodology: learning as part of a process that requires the recognition and use of different types and levels of language, be they academic, scientific, technical, casual, or non-native languages. In the case of Kosen, using English as a means of teaching mathematics—of solving mathematical problems and explaining the process of solving those problems—provides a reason for learning English beyond the usual test-oriented approach, as well as a sense of authenticity to non-native-language lessons.

Using CLIL to Achieve Authenticity

Students at Kosen want to learn subjects that relate to their future careers. As students of technology in Japan, the majority of students see subjects such as math and science as being more applicable to their futures than English. However, though they do recognize the importance of English, they don't perceive the English they learn in "English class" as being authentic, focused as they are more on vocabulary and grammar than on use. CLIL classes offer the best chance of addressing this need for authenticity. CLIL is not the same as L2 immersion. In CLIL, awareness of language as a tool for communication, not simply as the means of communication, is heightened even as English is used as a tool of communication between students and students, and students and teachers, to explore a subject.

By teaching mathematics in English, students perceive the material as directly related to their educational goals. Of course, a certain level of English skill is also required for graduation, but for the most part students do not perceive a need for English beyond graduation. We want to change that perception, so that students think of these classes as a chance to learn new materials related to their future and learn new skills for communication and for study, all of which appeal to the students' learning goals. Using CLIL in a science subject provides the current best possible model for achieving these desired results. Furthermore, and as has been observed in other educational institutions, CLIL motivates students to improve their language skills:

> Students are as keen to learn about content areas as they are to improve their language skills. They are also interested in learning study skills, which perhaps indicates a disposition towards developing greater autonomy. The fact that content was the most important aspect in defining authenticity implies that CLIL, through 'authenticity of purpose' delivers a greater sense of engagement to the students and allows opportunities for language focus to arise organically in the classroom situation. (Pinner, 2013)

CLIL classes can help students see English as a useful tool to understanding lesson content, especially in fact-based subjects such as math and science. Content can be a review of previously learned materials (wherein the focus is on the foreign language), or a slower, step-by-step examination of new content. This can address the problem that students and parents (and even other teachers) might view that any additional focus on learning English reduces time to focus on other subjects, subtracting from the limited resource of learning time. CLIL lessons can engage students more actively in learning, however, something that can appeal to both parents and teachers. CLIL courses may also help overcome the "teacher-centered" instruction that leads students to become less interested in school. In general, CLIL helps students feel more positive towards English (Lasagabaster, and Manuel Sierra, 2009).

Getting the students solving problems they want to solve can greatly improve their confidence and positive outlook towards further English learning. As Lasagabaster and Manuel Sierra (2009) remind: "Marsh (2000) highlights that CLIL programmes can nurture *a feel good attitude* among students, as the higher proficiency level achieved (irrespective of how modest it eventually is) may have a positive effect on their desire to learn and develop their language competence."

Given that Kosen students can choose to continue on to higher education or enter the workforce, our students don't have to study for university entrance exams. Thus, Kosen teachers can focus on teaching English as a communication tool, and not simply a means of achieving a higher score on a test.

Less is More: Increasing English Talk Time and Active Learning

To take the most advantage of the classroom environment as a place to use English, lessons should be kept focused on English for instruction and English through instruction (i.e., English learned through exploring content, not through the memorization of phrases apart from content). Any activities in the class will be kept to a minimum of new content, so that student production is kept focused on the use of English (hence, "less is more"). As students will invariably be encountering new content and new lexical items necessary for discussing this content, they will find themselves in need of repair strategies for overcoming times when useful or applicable English is not known. This presents us with another problem in Japan—and another opportunity to increase the amount of student talk time in English. In Japan, the burden of clearly communicating an idea is on the speaker, not the receiver. If something is not understood, the fault is seen as being on the part of the speaker, not the listener, and the burden of clarification is therefore on the speaker. As has long been the educational tradition in Japan, students perceive themselves as being in the role of listener. As Japanese listeners, if misunderstanding occurs, there is a a strong tendency to assume clarification will be provided by the speaker (usually the teacher). These assumptions are typical of passive learning and, unless changed by intentional practice, will continue to inhibit the learning of English as a tool of communication. So, the use of repair strategies—circumlocution, asking for clarification, using synonyms, etc.—needs to become a common part of our CLIL lessons. The necessity of this can be demonstrated to students by briefly exposing them to the different types of English throughout the world (different accents, different vocabulary, different intonation patters), and then explaining that outside of Japan, the burden of clarification is upon the listener: the listener must either ask for clarification, or indicate in some productive way a lack of understanding.

In a classroom where the focus of education is strictly on content, the time a teacher can devote to requiring students to use repair strategies is limited; however, in a classroom where the main focus is on getting students to use English as a tool of communication, repair strategies become an integral item in the toolbox of classroom interactions, as students seek clarification not only from the teacher, but from their fellow students.

So far, this is mostly theoretical. Let's look at an outline of the type of CLIL class we are proposing to use at the National Institute of Technology.

General Features of Our Proposed CLIL Class

I. Students come to class having studied the content for today's lesson. More on this later.
II. The teacher begins the class with a warm-up discussion or activity that is directly related, or even exactly the same, as the final discussion or task. No correction or feedback on errors should be given, just guidance and support if students are struggling to produce anything.
III. Students then work in groups to 1) explore lesson materials directly related to the content studied outside of the classroom, and 2) to produce content for other students in the class. At this time, the teacher acts as more of a learning assistant or guide.
IV. The teacher makes note of any content or English the students struggled with—to be addressed in subsequent classes, not necessarily in this lesson.
V. Students are encouraged to seek clarification.
VI. The teacher tells students the next lessons materials to be studied outside of class.

As you may note in this general outline, instruction, in the form of exposing students to new content, takes place largely outside of class. This is a key feature of a "flipped classroom. A flipped classroom is where students are introduced to lesson content outside of class, often, but not exclusively, through online videos. Students then come to class to practice with their fellow students and teachers. A flipped classroom offers the following benefits: 1) Increasing the number of times a student is exposed to instruction: once at home, once again in the classroom, and possibly once again by teaching other students; 2) students feel an even greater sense that English is relevant to their daily lives because the lesson materials are in English and practiced in English; and 3) class time can be devoted to using English, rather than just memorizing new terms and phrases.

The flipped classroom is a recent educational trend, and as with all trends it does have legitimate criticisms. In the context of a flipped CLIL class at a technology school, the most apt criticism is that a flipped classroom requires teachers to produce the online content, thereby increasing their already formidable workload. This is where online learning technologies can play a supportive role. By using a third party e-learning site, Khan Academy in our case, Kosen teachers and students will have access to a substantial quantity of proven, high-quality educational resources. While it does not provide learning materials on all subjects at all educational levels, Khan Academy does specialize in mathematics and science materials for the secondary education level, thus making it ideal for use at Kosen.

The benefits of Khan Academy and suggestions for ensuring students prepare for class will be detailed later. For now, let's look a more subject-specific CLIL lesson in a flipped classroom, using an online, e-learning resource.

Outline of Sample Introduction to Maths Lesson

A. Students are given two things to do outside of the classroom on the Khan Academy site:
   1. Translate into Japanese from English key vocabulary.
   2. Watch a video about how to solve this type of math problem.
B. In the following class session, at school, the class begins with a mathematics problem. The problem should be simple—simpler than the students' current level of mathematical ability. The main focus is on getting the students to explain the process of solving the problem.
C. A warm-up activity related to today's content. The main goal here is getting students to use English in the classroom, but also to provide some models of production for use later on in the lesson. Feedback should be limited to praising production and using examples of student generated English to illustrate effective communication methods.
D. Students would then read a brief article about the subject. At this point, the teacher might take time to highlight key or potentially difficult lexical items and ask students to provide clarification, or even to set up an activity where students must ask other members of class for clarification.
E. In groups, students would then identify parts of the equations or graphs.
F. Group production: Different groups create problems for other groups to solve. Ideally, the initial warm-up activity near the beginning of the lesson and this final group production/discussion should be similar.
G. Feedback/clarification from the teacher.
H. Finally, next video and vocabulary are assigned to students.

The above outline is only a suggestion. Actual content of the in-class interactions between students and teacher is, and should be, entirely up to the creative power of the teacher.

Potential Benefits and Drawbacks of Our Flipped Classroom

In a flipped CLIL class, students take on the role of teachers, creating content, assisting fellow learners, and even clarifying challenging lexical items. This is essential to promoting a more active learning role in the students, and to increasing their English talk time.

Additionally, a flipped classroom presents the following potential benefits: 1) Students feel an even greater sense that English is relevant to their lives. 2) Class time can be devoted to *using* English, rather than memorizing new terms or phrases. 3) Because lesson content is viewed outside of the classroom, parents have greater access (should they want it) to what their children are learning—and since these students are learning something in English, the parents might then get a more positive sense that English is something integral to their children's lives.

However, one of the key criticisms raised of the flipped classroom is that students may come to class without having adequately prepared. Indeed, some students may not view the lesson materials at all, but instead rely on their group members to support them. This is a powerful criticism, as it is often true.

The flipped classroom model assumes students willingly, and consistently, prepare for the following class. We teachers know this cannot be true all of the time. What can we do about this? Our class will employ two strategies for overcoming this difficulty: 1) require students to print screenshots of their Khan Academy points total to confirm that they at least accessed the site, and 2) have group members assign points to each member of their group, rating that member's contribution and preparedness. In this way, the teacher has a tool for tracking student preparation outside of class and for tracking student participation inside of class.

Taking advantage of the Khan Academy's points and badges system provides teachers a rough guide to student progress through the lesson materials. This same, game-like system provides students an additional motivation for viewing lesson materials outside of the classroom, independently, and this is one of the principal reasons we are attracted to using Khan Academy as an online, e-learning resource. Another advantage of Khan Academy is that it overcomes another criticism of the flipped classroom, to whit: that teachers must make the additional, online materials for students to view outside of class. This is not true in a flipped class using Khan Academy, however.

Why We Choose Khan Academy

The principle reasons we choose to Khan Academy's online materials are as follows: 1) lesson materials are already available in a wide-range of scientific and mathematical disciplines; 2) these materials are high-quality, created by educators, peer-reviewed, and edited according to user feedback; 3) each video is accompanied by a detailed, time-stamped transcript students and teachers can review any time. Also, the videos tend to be short (5-15 minutes on average), and each video is followed by a question and answer section that provides additional insights into a topic. The videos and other instructional materials are organized into educational progressions, facilitating lesson and module planning.

In terms of student motivation, Khan Academy is an excellent resource. Watching a video earns the student points, which can go towards badges and awards on the site. This sense of gaming, of play, and of competition, can all be utilized by the teacher in a variety of ways to encourage students to view the materials, review, or to even explore other related materials offered by the site.

And, of course, the site is free to join and use.

In a study examining how a group of schools in California used the e-learning site to augment their mathematics program, SRI Education observed the following positive effects:

- Filling in gaps in learning and shoring up weak spots from past instruction.
- Students tracking and monitoring school work to hold themselves accountable for their performance.
- Spending more time in peer teaching and collaborative work with classmates.
- Receiving more opportunities to direct their own learning.
- Allowing teachers to spend more time assisting individual students or small groups of students. (SRI Education, 2014)

SRI Education also noted that students perceived themselves as more independent in the learning process when they used Khan Academy, more engaged during such sessions, and in general enjoyed the experience (SRI Education, 2014).

At Kosen, if we cover material on Khan Academy that students already be familiar with, there's the strong, desirable possibility that this additional instruction will fill in aspects of the knowledge that the student may have missed or struggled with previously. As Clive Thomson, writing for WIRED magazine, notes: "Several students I spoke to also pointed out that Khan is particularly good at explaining all the hidden, small steps in math problems—steps that teachers often gloss over" (Thomson, 2014).

Khan Academy is an excellent resource for busy teachers seeking to boost active learning while increasing student motivation to learn. This is exactly what we are aiming to do at Kosen, with the added goal of increasing the perceived authenticity of the English students are learning. Khan Academy's most valuable materials and tools are in the field of mathematics, but a wide-range of subjects in the sciences are available.

Why We Focus on the Sciences and Maths in CLIL

Our focus for CLIL classes tends to be on science and math because we believe the students see these as directly related to their educational goals and their future, thus increasing perceived authenticity and motivation. Also, the English used to discuss these subjects can be tailored to fit student needs without becoming unnatural. Our students already have some mastery of the subject materials, and thereby can feel more confident approaching the subjects in English. By using English to study materials students are already somewhat familiar with, we teachers have the chance to provide a potential, beneficial review of the subject. Also, in the words of our own CLIL teachers: "When it comes to technical terms, studying the sciences in English is not only more efficient, but easier."

Furthermore, CLIL lessons can benefit struggling students by providing lots of visuals and step-by-step instruction. As Ute (2012) writes: "learning outcomes improve as more lessons are taught in the L2 (e.g. Bournot-Trites and Reeder, 2001)." In the process of exploring a topic in a second language, there are more opportunities for students to actively engage with the materials. But for CLIL to be most effective, teachers need to receive an adequate level of training, and additional training can improve overall lesson planning and implementation. The concern then becomes: How to do all of this without increasing the workload of our already overworked teachers?

As noted, using a third-party website such as Khan Academy is one means by which we hope to minimize any increased workload on busy teachers. CLIL classes can also take some of the teaching burden off of teachers by having instruction focus more on scientific or mathematical content and less on "the nuts and bolts" of English, thereby allowing content teachers to design lessons on subjects they already have some expertise in, rather than having to struggle to create more content focused exclusively on learning English. An added bonus of this process might be that because CLIL teachers must focus on presenting material in comprehensible and useful English, lessons may become more effective in relaying content. Still, adjustments to teaching schedules will likely be necessary in order to provide CLIL teachers adequate preparation time. CLIL teachers can then seek input from English teachers instead of having to produce everything on their own. Collaboration can become an effective means of reducing an individual teacher's workload. As Ute (2012) noted in a study of the use of CLIL in schools in Europe, the collaboration necessitated by an increased use of CLIL can reduce the burden on teachers:

> In order to compensate for additional time spent on preparing CLIL lessons and materials, all participating schools granted each ProCLIL teacher a one-hour reduction in their teaching load. Additionally, the project team supplied teachers with published and team-created learning materials. Nonetheless, ProCLIL teachers unanimously reported having to spend considerable time in preparing CLIL learning materials. *Half of the ProCLIL teachers worked alone at their schools and encountered more difficulties than those working in teams.* (Emphasis mine)

At Kosen, we hope to establish a system where native speaking English teachers are always available to advise CLIL teachers on lesson planning and implementation.

Survey to Measure Student Motivation

In order to gauge the effect of our proposed course, we will conduct two surveys. The two surveys will consist of statements with which the students either agree or disagree to differing degrees. One survey will be carried out prior to the start of the course, and the other survey will be conducted near the end, or after, the course is finished. These surveys aim to measure the individual student's motivation for learning English.

The surveys will consist of 16 statements, all in Japanese (the students' first language). Eight of the statements are our target statements, eight are to blind the students somewhat to the nature of what is being measured. On the survey, the questions are mixed together, but for clarity's sake they have been separated below:

Target Questions

1. I will use English in my future career.
2. I want more chances to use English outside of school.
3. I see English as relevant to my daily life.
4. I make an effort to seek out resources for studying English outside of my regular school work.
5. Speaking and understanding English helps me understand the subject material better.
6. Learning another language helps me to be a better person.
7. My friends and peers see English as important to our future.
8. People outside of school (parents, friends, members of my community, etc.) do a good job of helping me understand how English is relevant to my life after graduation.

Blind Questions

1. The school provides adequate chances for me to use English.
2. My English lessons at Kosen are interesting.
3. I want the teachers to use more English in the classroom.
4. Speaking English in the classroom interferes with my understanding of the subject material.
5. I enter the classroom expecting to participate in discussions or small group work.
6. I want the teachers to provide more explanation of key points in Japanese as well as English.
7. I feel prepared to speak English in the classroom.
8. My school is trying hard to provide me with chances to use English.

Students agree or disagree with the statements on a scale of 1 (strongly disagree) to 10 (strongly agree).

With this survey, we hope to measure a significant increase in motivation to learn English over the course of a semester, which would indicate a success on our part to foster a sense in students that English can be both a useful communication tool, and an important part of their daily lives.

Conclusion

Our immediate goal for implementing a flipped CLIL classroom using third-party e-learning materials is to increase our students' use of, and exposure to, English. We believe the best means to achieve this is to increase the perceived authenticity of the English students are exposed to in our classrooms. By studying, in English, subjects the students recognize as directly related to their immediate learning goals and future careers, we seek to increase the students' motivation to learn, and engage in, English. The current educational climate of Japan fosters an image of English as important to academic success, even to future potential careers outside of Japan, but not necessarily an important tool within Japan. The self-perpetuating stereotype that Japanese people are not good at English further demotivates students to make additional efforts to learn this second language. Furthermore, in Japan, though the government is stepping up efforts to increase the amount of English education students receive in school, there is a sense from parents and teachers that this increased emphasis on English will detract from other, more necessary fields of study, fields of study that directly contribute to a student's future career. There is a sense, also, that studying other subjects in English may reduce the effectiveness of instruction. This reflects a stereotype in most cultures that bilinguals are less likely to achieve success in scientific and creative fields. But, as Hugo Baetens Beardsmore (2008) so aptly points out in "Multilingualism, Cognition And Creativity": "if we take a closer look at the number of creative people who were at least bilingual, if not multilingual, the implicit superiority of monolingual individuals can be challenged." Add to that the simple fact that most successful scientists tend to be multi-lingual—"When asked how many of his contemporary Nobel Prize winners were bilingual, Ilya Prigogine (Nobel Prize for Chemistry, 1977) who spoke Russian, French and English and taught through French and English, replied, « the majority »" (Beardsmore, 2008)—and you have a formidable argument against the monolingual bias.

If we Kosen teachers can expose our students to this fact, and that an increasing number of Japanese engineers and scientists use English in their work despite living in Japan, we stand a better chance of overcoming the notion that English is simply a foreign language to be studied for entrance examinations or for writing grant or patent proposals. By using CLIL, we can increase our students' motivation to learn English, yes, but also increase their motivation to learn other subjects more actively and more independently:

> Students are as keen to learn about content areas as they are to improve their language skills. They are also interested in learning study skills, which perhaps indicates a disposition towards developing greater autonomy. The fact that content was the most important aspect in defining authenticity implies that CLIL, through 'authenticity of purpose' delivers a greater sense of engagement to the students and allows opportunities for language focus to arise organically in the classroom situation." (Pinner, 2013)

By combining CLIL with a flipped classroom style of teaching, and using high quality e-learning resources such as Khan Academy, we can enable our students to perceive English as a living, useful, tool of communication.

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Creating a Self-Directed Learning Experience in Laboratory Practicals through a Project-Based Learning Approach

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Abstract

The modern engineering workplace is ever changing with rapid advances in process automation and adoption of digital technologies. Engineers have to work on increasingly complex tasks in an environment that requires them to adapt and integrate new knowledge and technologies quickly in their workplace. It is not sufficient for Engineers to just be technically savvy in this new work environment, they must also be also be self-directed learners who possess lifelong learning skills in order to stay relevant.

This paper outlines the design of a Project Based Learning (PjBL) approach used in the Diploma of Chemical and Biomolecular Engineering (CBE) in Ngee Ann Polytechnic. This learning experience serves as a framework to equip students with relevant technical skills and with sufficient opportunities to shape them to be self-directed and confident problem solvers.

The PjBL draws on multiple unique features, which include learning in real world context, self-directed learning, and the design to allow for failures. In this instance, the PjBL is a collaboration with National Parks Board (NParks) (https://www.nparks.gov.sg/) for the Water Quality Analysis laboratory where students get to work on an authentic project. Elements of "Experiential learning" were used within the project as students engage in an iterative process to refine their project approach. Students are immersed in a "concrete experience", engage in "reflective observations", gain new ideas and knowledge through "abstract conceptualization" and put their ideas into "active experimentation". These features combine to create a more integrative and meaningful learning experience for students by blending classroom theory with active experimentation.

Student performance and feedback on this PjBL experience have been positive. Assessment results showed the quality of students' reports through the PjBL experience to be comparable to their reports from practicals conducted in the more traditional format. In addition, students also provided feedback that they felt that they had acquired the necessary domain competencies, become more aware of the environmental issues, and had also developed skills in team work and time management.

Keywords: *project-based learning, self-directed learning, problem solving, experiential learning*

Introduction

Chemical and Biomolecular Engineering (CBE) is a three-year diploma course in the School of Life Sciences and Chemical Technology (LSCT), Ngee Ann Polytechnic which integrates biological and chemical sciences with engineering concepts. The course prepares graduates for careers in a wide range of industries, including oil and gas, chemical, pharmaceutical and environment. The Singapore Economic Development Board published the Industry Transformation Map (MTI, 2017), that provided a roadmap for Singapore's future development as a globally competitive and leading Energy & Chemicals hub. The drivers to this transformation include the increasing emphasis on innovation across the value chain as well as the adoption of emerging technologies, for example in advanced manufacturing and digital technologies. To remain relevant, professionals in the industry must be nimble and continue to upskill themselves in these emerging technologies. It is therefore imperative to equip the CBE graduates with the critical lifelong learning skills and mindset.

Preparing Graduates for future work environment through Project Based Learning (PjBL)

In a conventional engineering educations setting, it is common to organize the learning of technical skills during practical sessions through a fixed learning path with a rigid set of standard instructions and procedures to follow, and with the use of controlled and well-defined scenarios under the guidance of a lecturer. Students would then have to complete either a worksheet or group report to demonstrate their understandings of the session. However, this conventional approach in delivering engineering practicals is becoming increasingly inadequate in preparing graduates for the 21st century workplace as it provides a limited exposure on the design and synthesis aspects of engineering (Duderstadt, 2008). The approach offers few intentional opportunities for students to encounter complex and industry-authentic issues, in which they would have to integrate and apply engineering concepts to create a feasible solution. Without these experiences, graduates would lack the ability to identify and acquire new knowledge and skills, as well as being under-equipped to undertake any problem-solving or continuous improvement opportunities in their future career.

This paper elaborates an example of how a PjBL approach was used to transform the learning of *Water Quality Analysis*. The paper provides insights to the students' overall learning experience as well as qualitatively assesses the benefits of the PjBL format in comparison to traditional practical. In addition, the paper also attempts to validate the quality of learning design of the PjBL through an analysis of summative assessments, including the final report and practical test results.

Transforming the Learning Experience

Feedback from the process industry partners, including chemical, petrochemical and pharmaceutical industries, pointed to the need for more curriculum opportunities for students to practice integrating and applying the knowledge and skills in the context of as-close-to real-world environments and issues (CBE, 2016, 2018).

In response to this, the CBE team designed a framework to create integrative curriculum opportunities in practical sessions that allow students to acquire problem solving skills using a Project Based Learning (PjBL) approach as the key pedagogy (Figure 1). This framework also aims to develop students into confident professionals with a lifelong learning mindset.

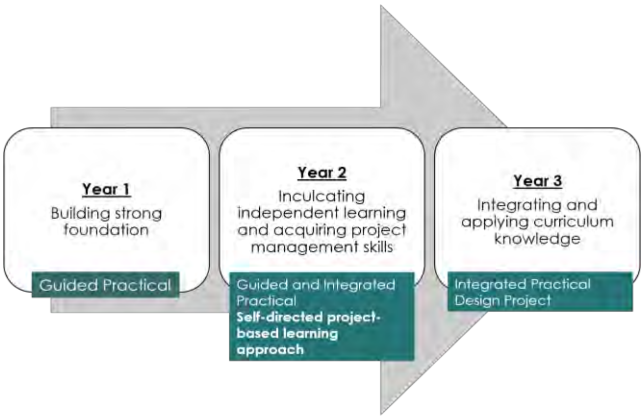

Figure 1: CBE Framework for Building Competencies Through Practicals.

The new PjBL approach extended its focus from the development of technical skills, to include the development of key "softskills" by shifting students learning:

From
- a controlled laboratory environment,
- instructor-led learning, and
- lecturer-designed failproof step-by-step instruction

To
- learning in a real-world context, with
- self-directed learning opportunities, and
- student-designed approaches with possibilities of failures and opportunities to learn from failure

PjBL —Pedagogy & Practices

The PjBL transformation aims to develop students' competence and confidence in handling complex and industry-authentic issues. Hence, a real-world context for the collection and analysis of water quality was used as an anchor for the overall lesson design. In addition, the PjBL activities also incorporate elements of experiential learning such as active experimentation, concrete experience and reflective observations as the team agreed with Kolb that learning is a continuous process grounded in experience and will become more effective as students go through an iterative process of these three stages together with an opportunity to conceptualize the experience (D.A. Kolb, 1984; A.Y. Kolb and D.A. Kolb, 2009).

Another important consideration in the design of the PjBL approach is the expected increase in the level of difficulty of the project as it becomes more open-ended due to the "real-world" nature of the task. This change in the design of the project will impact students' performance. To this end, the scaffolding of challenging tasks in PjBL took the form of a facilitative teaching, where subject matter experts interacted with the students to help them learn and acquire skills in stages, as well as to construct meaningful reflection of the activities by themselves. This mode of teaching will help students expand their capability by taking on increasingly challenging tasks that can be accomplished with guidance as noted by Vygotsky (1978) in his elaboration of the Zone of Proximal Development theory. Hammond and Gibbons (2005) also pointed out that the selection and sequencing of learning tasks as well as the design of the participant structure is crucial in the achievement of learning objectives.

PjBL Implementation

Table 1 shows an overview of the learning process, available learning resources or collaborative tools for students and the types of assessments used.

Table 1: Overview of PjBL Process for Water Quality Analysis Practical.

PjBL Stages	Learning Activities / Resources	Type of Assessment
Phase 1: Learning in real-world context – Problem statement	Facilitated discussion	-
Phase 2: Self-directed learning – Project discovery and planning	Technical videos Narrated powerpoints Padlet for online collaboration	Proposal presentation – Summative
Phase 3: Design to allow for failures –	Site visits	Lecturers' feedback –

Site sampling + lab analysis	Building of water collection device Sample collection and analysis Facilitated discussion	Formative
Phase 4: Reflection and feedback	Fishbowl discussion	Individual reflection – Formative
Phase 5: Project conclusion and report submission	Google drive and google document	Final report and practical test – Summative

Phase 1: Learning in Real-World Context

The use of real-world contexts helps to stimulate students' interest in the subject matter as they are able to see their knowledge and skills being applied a practical manner. Vygotsky (1978) highlighted that the level of interest has a proportionate effect to the width of the Zone of Proximal Development, i.e. skills areas that students can develop under the guidance of a knowledgeable person. At the same time, real-world contexts also bring students into meaningful contact with the profession and the industry they will be working in (Lombardi, 2007).

To create this real-world learning experience, LSCT partnered the Singapore's National Parks Board (NParks). NParks is the lead agency for greenery and biodiversity conservation in Singapore and aims to conserve representative ecosystems in land-scarce Singapore. The partnership provided an opportunity for students to take part in NParks' on-going project for the conservation of marine biodiversity in Singapore's coastal water and beaches. Particularly, students contributed on the selection and measurement of critical water quality parameters such as pH, total suspended and dissolved solids (TSS and TDS), dissolved oxygen (DO), biochemical, and chemical oxygen demand (BOD and COD), which will be used as a gauge to the health of the ecosystem in Singapore's recreational beaches. Working with a real industry player and seeing how their work could contribute and benefit the community helped build in students a greater sense of purpose for their learning.

Phase 2 : Self-Directed Learning Opportunities – Project Discovery and Planning

Knowles (1975) defined self-directed learning 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".

The design of learning activities in this phase was intended to provide students with multiple elements of choice to proactively carry out their project and learning process. In drafting their project plan, students would have to identify and systematically integrate multiple sources of information, as well as develop and present the relevant set of criteria to provide a rationale for their proposal of the various aspects of the projects. Students were also expected to learn the technical skills and analytical tools through video instructions independently. Through these activities, students would develop and internalize professional attributes which will be integral to their future career in the field of engineering, including rational thinking, active decision making and accountability, as well as confidence in working with new or unfamiliar equipment and techniques.

An outline of the self-directed learning opportunities included in the PjBL activities are as follows:

- Provision of remote learning video resources for self-paced learning and familiarization of the technical skills and analytical tools.

- Evaluation of formal guidelines of water quality standards. Students have to compare the different available standards based on the country and the type of water body for adoption, prior to making their choice of the standard and parameters they would use.

- Flexibility on the choice of sampling tools to collect the water samples. Students have to construct a prototype of the sampling tool, taking into consideration the site requirements for sampling, and the time and resources they have. In general, students have to figure out that their sampling device should allow water collection from mid-depth, without capturing unwanted surface water in the process. The collection procedure should also consider environmental factors and pollution sources at the site which may affect the water quality during sampling. In addition, students have to propose a suitable method to store their samples to minimize any microbial activity prior to the laboratory measurements.

- Flexibility to decide some aspects of the experimental protocol in consideration of possible limitations from available analytical equipment and/or reagents, including their suitability and measurement ranges.

At the end of this phase, students would present their proposal, and elaborate on the sampling technique, parameters to be measured, experimental approach, water quality standards used, possible sources of pollution, risk assessment and project timeline. This summative assessment is an important checkpoint for students to receive feedback from lecturers and peers on possible areas of improvement.

Phase 3: Design to Allow for Failures – Site Sampling + Lab Analysis

In this phase, teams would implement their plan to collect water from the designated sampling point using a prototype of their sampling tools. Teams will then proceed to carry out measurements on the water sample and subsequently evaluate the quality of their results.

The design of this phase incorporated elements of experiential learning as elaborated by Kolb (A.Y. Kolb and D.A. Kolb, 2009). As the PjBL draws on a real-world scenario, students would go through a realistic and “concrete experience” of the difficulties in implementing their initial project plan. Due to the uncertainty and complexities inherent in the PjBL, e.g. the use of coastal water sample with a complex composition, sampling site limitations, etc, students would not typically succeed in their first attempt. Students would have to do a careful reflection of what they observed in their attempts (reflective observations) to note what has or has not worked out as intended. They would then have to “actively experiment” on multiple approaches to complete the project. By getting students to go through this iterative cycle, students’ learning become more grounded in experience, which also provided the opportunity for them to embrace and learn from failures. John Dewey (1933) noted that designing learning to leverage on failure would further enable students to experience the essence of experimentation and discovery – to try, fail, learn from failure, make informed adjustments, and try again. This would be crucial for their development as professionals in the field.

In this phase, it is communicated clearly to students that failure in the water analysis is possible and is part of the learning experience in arriving at the desired outcome. To manage the fear of failure, ample formative feedback are provided by the lecturers to support students in their analysis of the reasons for the “failure” and how to rectify any “errors”. Students are assured on the opportunity to repeat and improve their measurements within the project time frame and will not be penalized on the number of attempts. With a chance to repeat their tests, students can focus on solving their problems and develop the necessary analytical skills.

Phase 4: Project Conclusion and Reflection

In this final phase, students work collaboratively to analyze their results and provide their conclusions and/or recommendations through a final report. Students are also required to reflect their experiences in each phase of the project and write what they have learnt in the process. This was carried out in a fishbowl setting, where each student teams would discuss and share their reflections with the class. Reflection allows them to deepen their learning, integrate new knowledge and experiences, and sharpen their analytical skills.

Effectiveness of PjBL

The effectiveness of the PjBL is reviewed through Students’ Feedback and Students Academic Performance.

Students Feedback

The benefits of adopting a PjBL approach are evident in the students’ written reflections. Students highlighted that the PjBL approach allowed them to take responsibility of their learning and work independently. Students also shared about the unpredictability of the real-world problem, the uncertainty of their test results and workability of their project plans, and the fear of failure were amongst some of the challenges they faced. Nevertheless, they felt that the experience was important to help them build confidence in dealing with unfamiliar equipment, failures and problems in the future.

Students were also more aware of the importance of developing various soft-skills to the success of their project. For example, they highlighted that working in a team requires good communication, the ability to find common ground to move forward despite differences in opinions and the importance of establishing trust to function effectively together as a team.

Qualitative responses in the institutional Module Experience Survey show that students have indicated an overall positive experience in the module. Students commented that the PjBL approach helped them gain experiences in three key areas, namely domain knowledge, civic-mindedness and generic skills. The collective number of positive feedback for each area gathered from students in the last two semesters (April and October 2018) are shown in Figure 2. It is encouraging to see that the PjBL yielded a higher level of civic-mindedness, which included a better environmental awareness and willingness to contribute back to the society.

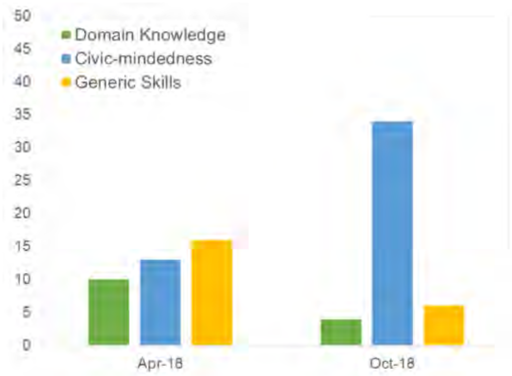

Figure 2: Number of Qualitative Module Experience Survey (MES) Responses.

A separate survey was conducted to further evaluate the effectiveness of deploying a PjBL approach. Students were asked to compare their experience in the PjBL relative to other traditional practicals within the same module. A total of 65 students responded to the survey and provided their feedback using a 5-point Likert scale with 1 and 5 representing "Strongly Disagree" and "Strongly Agree" feedback, respectively. Table 2 summarizes the percentage of "Agree" and "Strongly Agree" responses on the different areas surveyed. Overall, at least 70% of respondents agreed that a PjBl approach improved their motivation to do well and learn beyond the project, increased their confidence in future applications of the learnt project management and water analysis skills, and provided opportunity to practice problem-solving and troubleshooting skills.

Table 2: Percentage of Students Who Responded with Agreed or Strongly Agreed Rating (n = 65).

Category		% of Agree and Strongly Agree
Self-directed learning	Motivation to do well in the PjBL	72
	Learning beyond curriculum	80
Confidence level	For applying project management skills	79
	For demonstrating competence in water analysis skills	74
Opportunity to practice problem-solving and troubleshooting skills		74

In the same survey, students were asked to identify which of the PjBL elements were useful in facilitating their learning of the required knowledge and skills. The use of an authentic problem statement in a real-world context was found to be the most impactful in students' learning experience (Figure 3). This observation lends support to our notion that understanding how their work impacted the community would help to build a greater sense of responsibility for learning. Furthermore, a majority of students (85%) found that there was adequate support and facilitation by lecturers during all stages of the PjBL.

Figure 3: Relative Impact of Various PjBL Elements in Improving Learning Experience.

Students' Performance

An analysis of students performance was made so as to examine if th PjBL approach has an impact in students' performance. This included reviewing, analyzing and comparing the results of the two summative assessments at the end of PjBL, namely practical report and practical test against results of similar assessments for traditional practicals. The comparison was done for the same group of students to eliminate potential differences between cohorts.

Figure 4 shows a box-plot comparison of practical report marks of two different groups of students who took the module in April and October 2018. A statistical two-tailed t-test confirmed the null hypothesis that there is no significant difference of marks between PjBL and traditional practical reports for both April (n = 39, $p > 0.05$) and October 2018 (n = 57, $p > 0.05$) semesters.

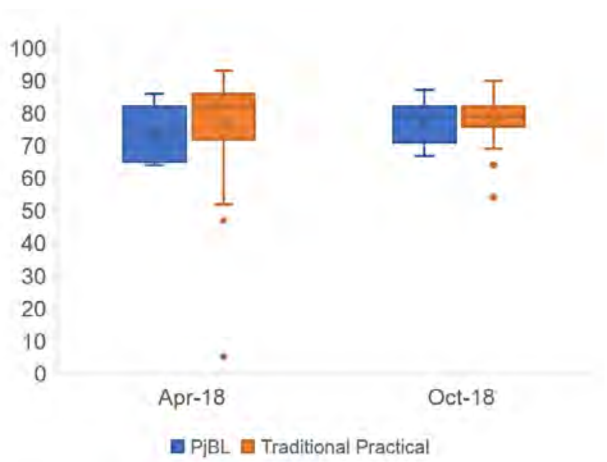

Figure 4: Box-Plot Comparison of Practical Report Marks between PjBL and Traditional Practicals.

The comparison showed that students were able to produce equally satisfactory quality of report despite the more challenging nature of PjBL. Furthermore, this observation implied that the scaffolding of learning activities and level of facilitation were adequate to ensure a satisfactory learning experience for students across different spectrum of abilities.

Figure 5 shows a box-plot comparison of practical test marks of two different groups of students who took the module in April and October 2018. It can be observed that the practical test results for PjBL topics have a wider range and a lower average in comparison with other traditional practicals. A statistical two-tailed t-test further confirmed the statistically significant difference of the practical test marks for both April (n = 36, $p < 0.05$) and October 2018 (n = 56, $p < 0.05$) semesters.

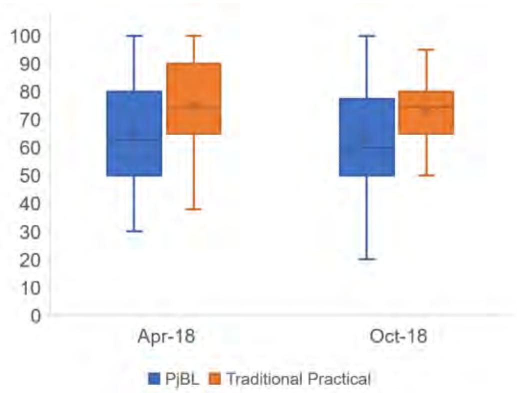

Figure 5: Box-Plot Comparison of Practical Test Marks between PjBL and Traditional Practicals.

It was previously noted in Table 2 that students responded having a greater level of confidence in performing the necessary technical skills related to water analysis. It is, therefore, interesting to observe the lower overall practical marks for PjBL in comparison to traditional practicals.

A possible reason for this contradiction may be due to the more involved learning in Phase 3 – Design to Allow for Failure in terms of the tasks to complete and the number of options students can explore to complete the project. As discussed before, this phase required students to learn from their failures and ensure adequate results for both on-site collection of water samples and the practice of water analysis skills in the laboratory. Due to the breadth of skills they have to learn at this phase, students may not have fully learnt the required technical skills for water analysis as reflected in the lower practical test marks for PjBL topics. This issue did not exist for a traditional practical format as it focused solely on the learning of technical skills. Further development of the PjBL on the issue would be explored in the format of flipped classroom, focusing on the review of technical skills.

Conclusion and Future Work

The deployment of a PjBL approach for the Water Quality Analysis practical provided benefits that go beyond the acquisition of technical skills. Students were able to practice important soft-skills, such as teamwork, self-directed learning and communication skills, and acquire experience in continuous improvement skills, such as project management and troubleshooting skills. All of these represent highly relevant and critical competencies required in the workplace.

The use of an authentic problem statement designed in partnership with NParks provided students with opportunities to practice integrating and applying their knowledge and skills to solving real-world problems. CBE students were able to take full ownership of their project, propose and execute their plans with minimal supervision. In the process, they gained the confidence to navigate unfamiliar environments and situations. The unpredictability and complexities present in the problem statement also created development opportunities to build students' resilience in face of adversity, sharpen their critical thinking and troubleshooting skills.

One possible limitation with the current PjBL is the use of presentation and final report as summative assessments. Future work is needed to re-design the assessment of the PjBL activities to focus more on the process rather than primarily on the product, where key elements of project management and design thinking could be emphasized. Besides, students may be too overly focused on achieving the intended water quality results rather than the learning of the water analysis skills. This shortcoming could lead to the lower average test marks for PjBL as compared to that for traditional practicals. It is important to communicate clearly to students that failure in the water analysis is possible and is part of the learning experience. The assessment could focus not merely on results alone, but also in the process, including how well they are able to recover from their failed attempts. Students need to analyze the reasons for the "failure" and how to rectify any "errors".

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Guidance utilizing self-analysis for completing application forms for students applying to overseas training programs

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Abstract

Students who wish to continue studying independently need specific goals that link their past, present, and future. Additionally, to ensure that they become valuable future human resources who contribute to society widely, they need to be familiar with both international community and familiar societies. However, students focused only on daily homework and regular exams tend to be less aware of the significance of their learning. This study examined the process associated with student self-analysis and the completion of an application form for a funded overseas training program with the aim of setting specific goals for learning related to sustainable development goals (SDGs).

The self-analysis teaching content sought to clarify the students'future image based on their past and present, for which interviews and self-research were employed to ensure that all the technical, social, and international issues the students were interested in were covered before creating the application form. An instructor taught the students the specific self-analysis methods and then conducted interviews to clarify some issues. In the five to ten independent interviews, the instructor examined each student's interests and asked them to think about the specific issues related to the SDGs. For the general application form, questions such as on the "motivation for the application" and "how to make use of experience after training" were asked, for which the instructor provided guidance to ensure completeness and clarity. The whole process from self-analysis to application form completion took approximately two months.

These initiatives have continued for three years and have been completed by 42 students in the first and second grade, eight of whom were eligible for the grant. The questionnaire results on the initiatives found that through the self-analysis, interviews, and research study, all students including those with not high achievement were able to clarify their specific goals related to the SDGs. In addition, 90% of students including those who were not subsidized showed improvements in their motivation for learning.

Keywords: *Self-analysis, interview, self-research, guidance, overseas training program, motivation*

Introduction

In the National Institute of Technology (KOSEN), it is common for a 15-year-old student to go to work after graduating from junior high school. The student may also transfer to a university at the age of 20, after studying for five years. Since KOSEN is characterized by the students' early learning in specialized fields rather than general areas of study, students who graduate from KOSEN shall have more expertise than those who graduate from normal Japanese high schools. However, students who experience the disadvantages of studying in KOSEN will have serious difficulties in terms of maintaining and improving their learning motivation. For students to experience the positive aspects of KOSEN, it is important for them to continuously learn independently in addition to the curriculum of the technical college. The consciousness that students should have for voluntary and continuous learning is their inherent "passion for accomplishing something." It is desirable that "something to accomplish" is perceived as a concrete task in the international community and familiar society; it should not be based solely on the student's personal preferences. Since human beings are originally living in a social group, they must be interested in social problems and their corresponding solutions. Additionally, "passion" is nurtured by the concrete actions that students have consciously and unconsciously selected, and the specific goals and actions they currently have. However, students tend to become desperate to complete immediate tasks and exams, often forgetting to have specific goals and passions in life.

This study examined the process associated with the self-analysis of a student. It examined the completion of an application form for a funded overseas training program, with the aim of setting specific goals for learning related to the sustainable development goals (SDGs). The subsequent educational effects were studied from the answers of the students to the questionnaire administered to them.

Methods

Table 1. The general flow of an application for overseas training programs

<table>
<tr><td colspan="2">Event</td><td>Student</td><td>Teacher</td></tr>
<tr><td colspan="2">Overseas training program briefing</td><td>Offer for application</td><td></td></tr>
<tr><td colspan="2">Pre-questionnaire</td><td>Answer</td><td>(Analysis)</td></tr>
<tr><td rowspan="5">Application preparation</td><td>Class 1 guidance by all</td><td>Attendance</td><td>How to Self-analyze and SDGs</td></tr>
<tr><td rowspan="4">Class 2 individualized guidance</td><td>Self-analysis</td><td></td></tr>
<tr><td colspan="2">Interview</td></tr>
<tr><td>Brush up</td><td>Writing guidance</td></tr>
<tr><td>Submission</td><td>Check</td></tr>
<tr><td colspan="2">Post-questionnaire</td><td>Answer</td><td>(Analysis)</td></tr>
<tr><td colspan="2">Notification of document screening results</td><td></td><td></td></tr>
<tr><td rowspan="2">Interview preparation</td><td>Class 3 guidance by all</td><td>Attendance</td><td>How to take an interview</td></tr>
<tr><td>Class 4 individualized guidance</td><td>Practice</td><td>Practice partner</td></tr>
<tr><td colspan="2">Interview screening</td><td></td><td></td></tr>
<tr><td colspan="2">Notification of acceptance/rejection results</td><td></td><td></td></tr>
<tr><td colspan="2">Study abroad</td><td></td><td></td></tr>
</table>

Table 1 presents the general flow of an application for overseas training programs. The students make an offer to apply right after the briefing session of the overseas training program. The teacher will make the students who have applied for the application work. This activity is broadly divided into application preparation (Classes 1 and 2) and interview preparation (Classes 3 and 4). The focus is on self-analysis and interviews of Class 2 (shown in bold). Classes 1 and 3 were taught in the form of lectures, while Classes 2 and 4 were taught individually. Individual guidance was provided to students through the cooperation of many teachers. In Class 1, self-analysis was done and explanations of the SDGs were given to all students. The students' goals here included: (1) knowing the method of self-analysis, (2) understanding the 17 goals defined by the SDGs, and (3) knowing which goals include the students' own interests. Since each goal of the SDGs is extremely broad, the interests of the students may be included in any of the abovementioned goals. Thus, the students' interests can be connected to global issues and their corresponding solutions. Moreover, the sense of mission of the students can be improved. Whenever self-analysis is being explained, teachers emphasize that students can "perform a self-analysis, thinking that their contribution can move the world." This instruction is important because many students lose their self-affirmation due to poor academic performance; if self-affirmation is lost, the students will not be able to develop successful careers. Furthermore, when a scholarship is provided in an overseas training program, teachers instruct students to "think about what their career can contribute in the future." This is because students focus on what they want to do and do not think about the positive impact of their future career on the society. In this way, students can perform self-analysis while at the same time putting together their social mission.

Class 2 focuses on self-analysis and interviews. Students perform self-analysis work whenever they can relax mentally. For example, students can do self-analysis work after lunch on a holiday. The self-analysis imposed on students is crucial for them to concretely express what they are interested in and share what they want to do in the future by dividing their thoughts and ideas into the past, present, and future. Since most students are not good at materializing, we shall introduce concrete examples such as teachers providing current topics based on the self-analysis results of students in interviews conducted after their self-analysis. In the process of embodying the students' goals, the teachers encourage them to study the current topics and learn specific tasks and approaches. Here, students investigate some topics and teachers encourage them to learn certain tasks and initiatives. Students repeat the interviews and surveys 5 to 10 times, according to their independence. Teachers explain to their students that their interests are "a part of the global task" and that their actions are useful for the society and the world. Students start writing the application form after they have already set specific goals. If the application did not describe what the student was trying to say at the time of the interview or if there was insufficient concreteness in the things mentioned in the applications, teachers shall indicate each time and immediately make them revise their application. Thus, teachers encourage students to voluntarily submit applications.

Classes 3 and 4 involve preparations for interviews incorporated into the assessment of overseas training programs. Interviews vary depending on the program: video screening or omission. After passing Class 2, students can talk about their thoughts in front of the teachers and can subsequently set specific goals. Therefore, in Classes 3 and 4, teachers will teach students how to express their enthusiasm for overseas training during an interview with the examiner. Specifically, as a non-verbal technique, teachers will teach the students how to actively listen; this technique being taught includes a slightly leaning posture, talking with the eyes of the examiner, and an appropriate hammer or nod. In addition, as linguistic techniques, students are taught to clearly and enthusiastically state their conclusions first.

This kind of technique is nothing more than a baking blade before the interview. However, it is expected that students who use non-verbal techniques will be more effective in "making them feel more enthusiasm for overseas training," than those who do not. In the case of a video review, the teacher prepares the student to finish exactly at the stipulated time. This shall likewise train the student to show enthusiasm.

Results and Discussion

This activity has been implemented with 42 students in the last three years and is still improving with repeated student guidance. To evaluate the effectiveness of the efforts, we administered a questionnaire to 26 first- and second-year students who took Classes 1 to 4 in 2019.

The first question was, "Did your motivation to study and reach your goals improve?" Out of all the respondents, 96% responded positively, with answers varying from "quite increased" to "slightly increased." With regard to the question, "Did you have a specific goal?," 12% of the students were unsure whether they could or could not do it; however, 88% answered they could. Therefore, this activity is considered to be effective for most students. Furthermore, in response to the question "How did you feel during the course?," 50% of the students chose the option "enjoyed/excited," while the other 50% chose "it is a thorny issue for me." Self-analysis is effective in raising the motivation of students for self-actualization. However, some students look at the reality by comparing their "desired self" with "the current (unreasonable) self."

In addition, students were asked, "Are you willing to study abroad even if you do not receive a grant by writing an application form?" From all the respondents, 42% answered either "sufficient" or "some," while 58% answered "neither." Although the application form was written for obtaining a grant, 40% of the students were still willing to continue at their own expense even if they do not receive the grant. It is said that the more effort put into the past, the greater the passion you will have at the moment. Furthermore, passion is said to grow from continued efforts. Students are able to set concrete goals and have a certain amount of passion for those goals.

Students could set concrete goals related to SDGs relatively easily by taking classes on SDGs. By taking such classes, they become more aware of these goals. This is because whatever the students' interests are, they are more or less related to social issues. The items that were of relatively high interest in each goal of the SDGs for students were "safe water and toilets worldwide" and "let us protect the abundance of the sea." The area where our school is located faces the sea and is close to the mountains, so there is plenty of spring water for drinking. Therefore, residents in this area are relatively interested in water, and children are probably exposed to education. Using such regional characteristics of students for teaching will lead to the enhancement of career education.

To further evaluate the effect of these efforts, a questionnaire was administered before and after the training program. The participants included 26 students who took as subjects and 39 second-year students who did not take as controls. The questionnaire had a five-level evaluation system, with "5" being the most positive.

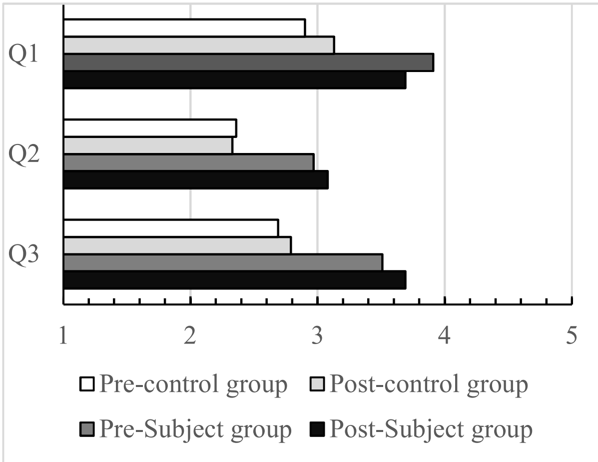

Fig. 1. A question regarding the students' interests in society.

Figure 1 poses a question regarding the students' interests in society. Question 1 is "I am interested in things other than the society in which I live (for example, the issue in a foreign country)," Question 2 is "I am interested in the economy of the area in which I live," and Question 3 is "I often read newspapers and watch TV news." All the questions were answered more positively by the subject group, and there was no significant difference between the subject and control groups before and after the approach. It was found that the students who attended this training program were more interested in society other than their own selves, as compared to the students who did not attend.

Figure 2 summarizes the results of the questions per group. The subject group answered affirmatively as regards the approach to evaluate the effect on the attendance to the program. Question 4 is "Do you think that you can do anything with your own power?" This question is intended to measure the self-competence of the students. In the process, the students who took the

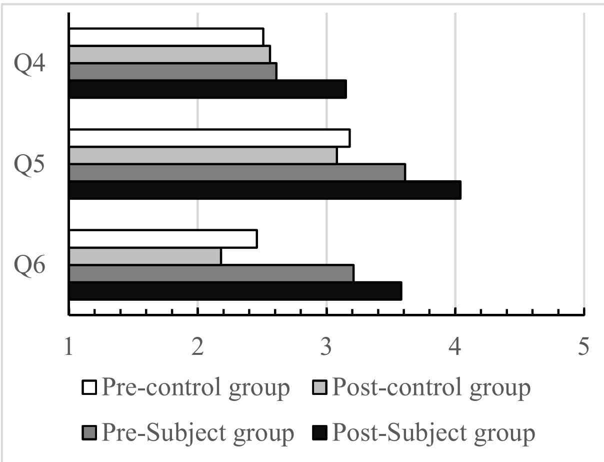

Fig. 2. Figure 2 summarizes the results of the questions per group.

training program set concrete and original goals they can do for themselves. They could improve their self-competence because such a goal does not involve anyone else. Question 5 is “Can you say your opinion in front of everyone?” This question is intended to measure the students’ confidence. Many students were not good at communicating their thoughts to others, even with teachers; they encountered difficulty in expressing their specific goals. However, it is considered that self-confidence can be effectively increased by having the students express their thoughts repeatedly in interviews and giving immediate feedback to develop their thoughts. Question 6 is “Do I have a clear vision of future work?” This is intended to measure the students’ motivation for a career. Many students were able to clarify what their future careers would be through the attendance.

Conclusions

In this study, we examined the effects of implementing the application preparation guidance to lower grade students using the application for overseas training programs. The efforts motivated most of the students to study and achieve their goals. Out of all the students, 40% were able to motivate themselves to want to study abroad even without receiving a grant. In contrast, it was found that 50% of the students had melancholic feelings because of the difference between their reality and the ideal future image they have in mind. Students who took the guidance tended to be more interested in society than students who did not. By taking the guidance, they had a clear view of noncognitive skills such as self-competence and self-confidence as well as a vision of a career.

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DEVELOPMENT AND PRACTICE OF INTRODUCTORY TEACHING MATERIALS FOR ELECTRIC POWER ENGINEERING FOR COLLEGE OF TECHNOLOGY

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Abstract

In this paper, a novel teaching material for the subject in "Electric Power Engineering" is proposed. There are technical colleges called KOSEN in Japan. The number of KOSEN is about 60 and Each KOSEN has been using unified curriculum called the Model Core Curriculum (MCC). Among many compulsory subjects based on MCC of Electrical and Electronic Engineering, we have a class called "Electric Power Engineering". This subject is offered to higher graders because the contents of this subject are the upper level based on the fundamental subjects such as Electrical Circuits and Electromagnetic Theory. It is the fact that KOSEN has its own curriculum-based educational system offering a lot of experiments and practical training to students. Despite that, the class style of Electric Power Engineering is non-interactive teaching, because the really necessary equipment for the class cannot be installed on campus. Therefore, while taking the subject, students can neither feel the huge amount of the power capacity the subject handles nor know the danger of it. It is necessary that more students will be interested in the above-mentioned subject and also that learning materials and teaching methods should be introduced. As a result of various trials, we have developed innovative teaching materials for introducing the subject. This material employs a board game simulation format, so students can learn with interest. In this time, it was confirmed that by applying the gaming simulation to the KOSEN students. They have been able to understand the learning goals represented by the difficulty of achieving 3E and the different characteristics of each country's situation. Consequently, it was shown that students could study global issues in environmental and energy problems beyond the learning targets using the proposed material.

Keywords: *Electric Power Engineering, 3E, Gaming Simulation, Energy Education, Model Core Curriculum*

1. Introduction

Japan has technical colleges called KOSEN and about 60 campuses [1], [2]. Each KOSEN had been using their own curriculum until a few years ago. For this reason, despite being a single organization, KOSEN hasn't been able to guarantee the quality of education at each campus. Then, in 2017, the Model Core Curriculum (MCC) [3] was formulated by KOSEN head office, and the basic educational contents in each engineering field were unified. Among many compulsory subjects based on MCC of Electrical and Electronic Engineering, we have a class called "Electric Power Engineering". This subject is offered to higher graders, because the contents of this subject is the upper-level based on the fundamental subjects such as Electrical Circuits and Electromagnetic Theory. It is the fact that KOSEN has its own curriculum-based educational system offering a lot of experiments and practical trainings to students [4]-[7]. In spite of that and energy education [8]-[10] is so important, the class content of Electric Power Engineering is a non-practical, because the really necessary equipment for the class cannot be installed on campus. Therefore, while taking the subject, students can neither feel the huge amount of the power capacity the subject handles nor know the danger of it. It is the frequent tendency that the Department of Electrical and Electronic Engineering has introduced a course system since the department covers a wide range of fields. It is necessary that more students will be interested in the above-mentioned subject and also that learning materials and teaching methods should be introduced.

As a result of various trial and error, we have developed innovative teaching materials for introducing the subject of Power Engineering. This teaching material employs a board game simulation format [11], [12], so students can learn with interest. A teaching manual that is consisted of computer application and web video has been prepared so that teachers whose major is not in Electric Power Engineering can also implement it. In this paper, we show the created teaching materials and the results of the practice performed in National Institute of Technology (NIT), Oyama College in 2019.

2. Teaching material design

2.1. Lectures on Electric Power Engineering at the National Institute of Technology

Two-credit classes in a half year of KOSEN give 90-minute lectures with 15 sessions. Therefore, the proposed teaching materials for the introduction of Power Engineering need to be completed in the 90-minute lecture. The Department of Innovative Electrical and Electronic Engineering in Oyama College, to which the authors belong, has three courses: environment and energy, robots and control, and information technology. Students belong to one of the courses. Among the courses offered, the specific subjects corresponding to "Energy generation, transportation, use and environmental issues" in the MCC are "Renewable Energy Generation" or "Power System Engineering". Mainly, the former deals with power generation technology, and the latter transmission and distribution technology. Currently, the general contents of Electric Power Engineering, which is equivalent to MCC's "Generation, transport and use of electric energy and environmental problems", are lectured at the first of the class.

2.2. Gaming Simulation and Learning Goals

The significance of using gaming simulation as an educational method is that you can experience difficult environments, situations and positions in the real world [13]. As mentioned above, the teaching style of general Electric Power Engineering is mainly a non-interactive lecture in classroom, and it is not a good atmosphere because students cannot easily understand the contents. In "Renewable Energy Generation" and "Power System Engineering" which include the contents of MCC, students learn technical knowledge and characteristics such as power generation and transmission methods. Furthermore, in these subjects, students are expected to have a correct understanding of Electric Power Engineering, including real problems such as 3E (Economic, Environmental and stable Energy supply) and generated power ratio (energy mix). Therefore, achieving the following two points, which make it difficult to understand and image real problems, is the learning goal of the proposed introductory educational materials.

Make students,

1) Experience the 3E trilemma problem and understand the difficulty of achieving it.
2) Consider various environments and understand the differences in power generation systems suitable for each country.

These two targets were set by one of the authors, because students will learn from the fact that the Protocol to the United Nations Framework Convention on Climate Change (COP) has not yet drawn up a new protocol since the Kyoto Protocol [14]. The authors hope that students will gain the international negotiate power to contribute to the environment as a Japanese engineer in the future by learning about the contents of 3E and the energy situation which varies from country to country.

In order to experience them through gaming simulation, it is necessary to model the 3E trade-off structure. Figure 1 shows the modelled 3E problem. The diagram shows the following trade-offs: Economics and environmental effects on power generation. Stable supply and environmental effects on the power grid system. Economics and stable power supply effects on fuel procurement. In particular, for stable supplies, existing teaching materials on power and energy

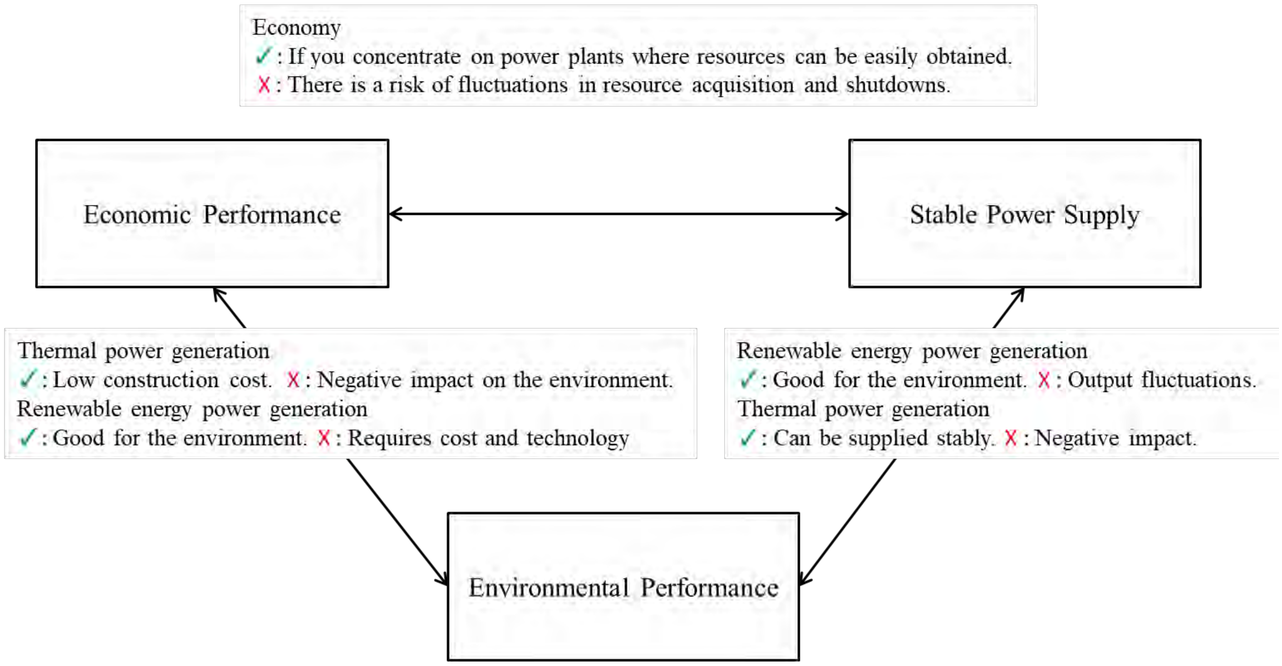


Figure 1. 3E problem (economic, environmental and stable energy supply) in this teaching material.

engineering often assume only power outages. On the other hand, the proposed material relates to the trade-off with the economy, which is one of the features.

2.3. Design and flow of teaching materials

First of all, the overall image of the simulation is explained. Each player (student) performs a simulation, assuming that they are appointed as a position in charge of national power generation business in a world (group) in which power demand is increasing. Players understand the characteristics of their country, such as the number of power plants, the power generation ratio (energy mix), and the source of fuel for thermal power generation, and make decisions such as the construction of power plants to meet 3E. At that time, they need to consider the power generation method and various events related to the amount of power generation such as irregular weather and nuclear power plant outage, and select a transition for the future from the current energy mix. In the end, the country with the most points for power supply stability (no power outages) and economy (large number of power stations) wins. Generally, 3 to 5 people are grouped into one group, and when there are 6 or more people, they are divided into multiple groups (world). If there are multiple groups, it is a group battle, and the group that is good for the environment (low CO2 emission) is the winner.

Next, the detail of the game is explained. First of all, the player selects a country. The countries that players can choose from are currently modelled on the United States, China, Canada, and Russia. Figure 2 shows the United States as an example. The explanation is shown in Japanese on the original sheet, but English translated version is used here. The same applies to Fig. 4 and 5. Each country has a set of initial resources, resource mining bonuses, and power plants according to the actual resource and power generation characteristics. In addition, the power balance of each country is adjusted by setting the technical level, which is an index required when constructing a power plant. After each player decides the country, the game starts. Figure 3 shows the game flow. Basically, this flow is performed until the CO2 emission limit is reached. However, if the lecture time is exceeded, it is possible to terminate the class halfway, and the group with the lowest CO2 emission at that time will be the winner.

At first, a game starts with the implementation of an event. The event consists of 15 different cards, and each turn is executed randomly by the game facilitator drawing the cards. Players need to construct power plants and acquire resources in response to the increase and the decrease of power generation and resources due to the event shown to each player. Let us some examples from Fig.4; the number of mining and reserves increase for fossil fuels (Fig. 4 (a)), abnormal weather leads to the reduction of power generation to the half quantity for renewable energies (Fig. 4 (b)), power generation stops for one turn for nuclear power generation (Fig. 4 (c)), and so on.

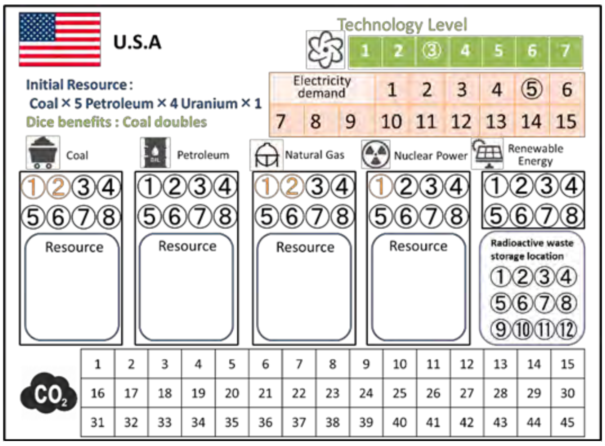


Figure 2. Example of country sheet used by players.

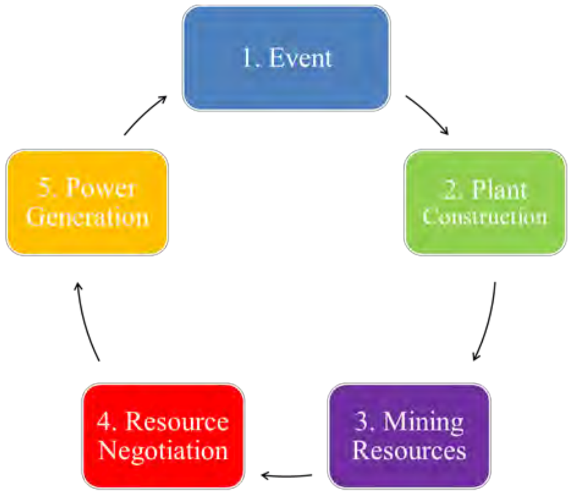


Figure 3. One-turn flow of the gaming simulation.

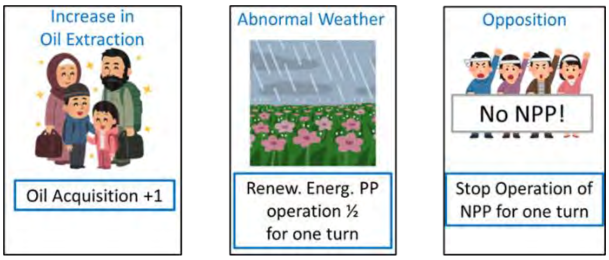


Figure 4. Event card examples. From left to right: Increase in oil extraction, abnormal weather, opposition to nuclear power plant.

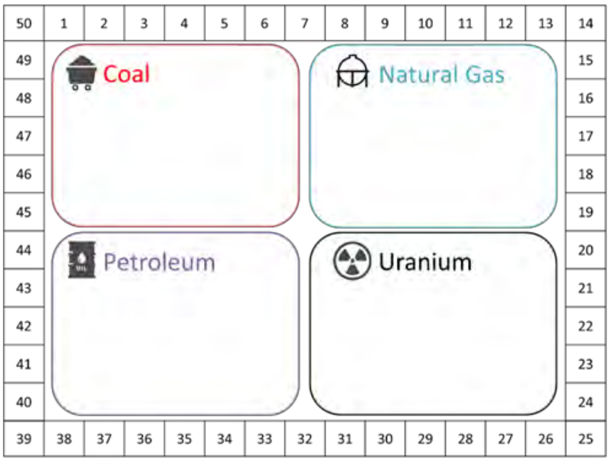
Secondary, the players consider the event and build a power plant to meet the demand. No money is set in this teaching material. Therefore, the resources and the level of technology used for power generation were applied to the construction of the power plant. Table 1 shows the number of resources, technology level, and CO2 emissions required for the construction of each power plant. When one power plant is constructed, one unit CO2 is emitted.

In the third resource mining, dice is used to obtain fossil fuel or uranium for nuclear power from the field sheet shown in Fig. 5. At this time, the acquisition rate and resource amount can be changed according to the

Table 1. Power plant construction conditions and CO2 emissions during power generation.

Plant Type	Required Resources	Required Technical Level	CO2 Emissions per Power Plant
Coal	1	1	1
Petroleum	1	1	1
Natural Gas	1	1	1
Nuclear Power	1	2	0 (Radioactive waste 1)
Renewable Energy	0	4	0

Fig. 5. Field sheet for gaming simulation.



number of people and the lecture time. After players have the resources, they can exchange their resources and radioactive waste by negotiation with other countries. Negotiations can be conducted with any country in the group, and the exchange rate is free at this time.

Finally, power generation is performed. When operating the power plant, various emissions per power plant are as follows: thermal power generation emits one unit CO2, and nuclear power generation emits one radioactive waste. In nuclear power generation, it is possible to discharge waste to the upper limit of the waste storage place in each country, but once the upper limit is reached, the power plant cannot be operated this concludes one turn. At the end of one turn, the players can increase their skill by one point. This flow is repeated, and the game ends when the total amount of CO2 emissions in the group reaches 100.

The ranking is determined by the following procedure.

1) The order of the group with the lowest total CO2 emission is preferentially higher.
2) In the case of a tie, apply -5 points × the turn that could not meet the demand in the countries in the group.
3) If it is still not decided, give 10, 8, 6 and 4 points in the order of the number of power plant constructions, and compete with the total points.

3. Application of gaming simulation to class in 2019

The above-mentioned gaming simulation materials were applied to the fifth grade students of the department to which the authors belong. The applied subject was one time (90 minutes) of the Power System Engineering, and eight students were divided into two groups. In the flow of the class of the day, we first explained the rules, then implemented gaming teaching materials, and finally explained the report tasks. The tasks of the imposed report are as follows.

<Report tasks>

(1) Examine the power plant ratio, resource distribution, and characteristics of the country where you played.
(2) Find out the differences between the gaming simulation and reality.
(3) Take a moment to look back on your actions subjectively about the game development. In particular, indicate any actions that benefit the entire world (group).
(4) State what the necessary viewpoints are and what should be considered in selecting a power plant to construct.

Tasks (1) and (2) aim to acquire knowledge by examining and summarizing how reality is reflected in the teaching materials. In addition, by researching the differences from reality, the student will be able to deepen the learning. The purpose of task (3) is to understand the 3E and national conflicts. Here, we also hope that subjective actions and ideas of face-to-face, which are the advantages of real board game implementation by multiple people, will emerge. Task (4) is set to recognize the learning goals described above and to determine whether they have been achieved.

In addition, the gaming simulation itself was also conducted for 15 students of the subject “Electrical Energetics” in the advanced course (a course after graduation from the KOSEN), and opinions on usability and understanding were collected. The students were divided into four groups.

The following describes the actual situation of the gaming simulation and the outline of the submitted report task.

3.1. Transition in CO2 emissions and actions of each player.

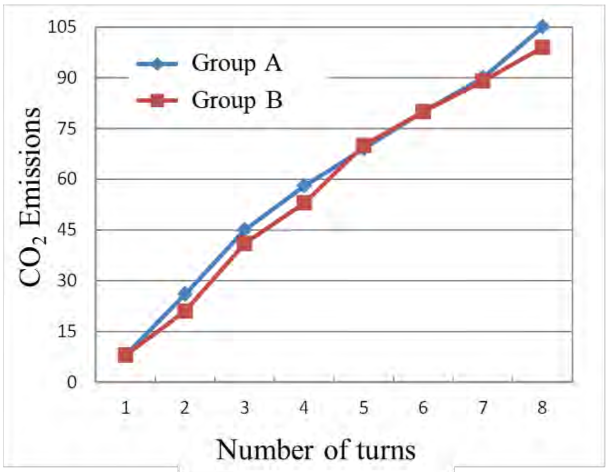
Figure 6 shows transition in CO2 emissions. In the implementation of the fifth grade (Fig. 6 (a)), Group A emitted a large amount and exceeded 100 points on turn 8. However, from turn 5 to turn 7, emissions from both groups were comparable. Both are the result of maximizing the construction and operation of nuclear power plants. After that, Group A reached the upper limit of the radioactive waste storage area on turn 7 and started thermal power generation on turn 8, with CO2 emissions exceeding 100 points, ending the game. Here, Group B had many discussions before taking action. Specifically, in negotiations, instead of exchanging resources, in some cases, they provided them for free of charge, and they were thinking about how to reduce global CO2 emissions and acting. In the submitted report, there were statements such as "We have accepted nuclear waste for the world free of charge" and "We have helped other countries that have been depleted because we have obtained a lot of resources." From these results, it is presumed that the players in Group B acted on behalf of the group based on their psychology of giving priority to their own interests and not losing to other teams. The results in the advanced course (Fig. 6 (b)) were almost the same.

3.2. Answers and Considerations of Submitted Report.

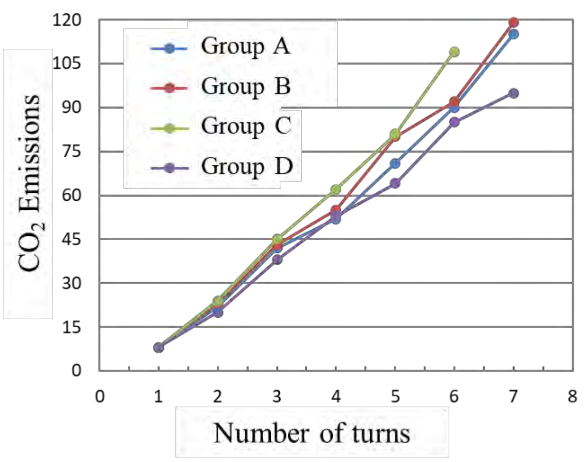
The summary of the report submitted by the student is described for each report assignment.

In Task (1), there were many cases in which what was required, such as the ratio of generated power, was examined using the Internet or literature and summarized.

In Task (2), the teaching materials set the CO2 ratio of coal, oil, and natural gas to 1. However, in fact, if coal is set to 1, oil was 0.8 and natural gas was 0.6. This is omitted in the teaching materials in order to simplify calculations, and was explained during the class. It also states that resource acquisition cannot be determined by dice. Certainly, reality is not a fixed random like a dice. On the other hand, out of 100 oil mines, the reality is that only 3 to 10 oil fields are profitable [15]. Therefore, in this teaching material, dice was using to set the situation.



(a) Results of fifth graders.



(b) Results of advanced course students.

Fig. 6. Transitions in CO2 emissions for each group.

In Task 3, as described above, “action for the world”, “no luck with dice”, and “difficulty in behavior due to the country's initial resources and power plants” were described. The students who participated this time attended a lecture called “Renewable energy generation” half a semester ago, and knew technical things. However, depending on the subject, although some students knew the current situation in Japan, they did not know the situation in other countries or the behavior according to it, so many seemed to find it difficult. In a global society, negotiation while understanding the situation of other countries is an important ability. As shown in the results of the gaming simulation and the descriptions from the students’ report, there is a possibility that students can also learn such negotiation power with this teaching material.

Task (4) includes “importance of communication between nations”, “dispersing the risks of nuclear and renewable energy”, “I learned that there is no universal power plant that can meet all of them”. Therefore, it was found that those answers match the learning objectives of this time.

From the above results, it was shown that the introduction of this gaming simulated teaching material to power engineering subjects is one of the effective learning methods..

4. Conclusions

In this study, we developed a gaming simulation typed teaching material that includes the contents of the MCC prescribed by the KOSEN head office, and allows students to learn the contents of electric power engineering more physically than before. By incorporating digital support such as computer applications and Web contents into the tutorial, the simulation can be more facilitated. In this time, it was confirmed that by applying the gaming simulation, the students have been able to understand the learning objectives represented by the difficulty of achieving 3E and the characteristics of the power generation system that differed from country to country from the implementation status and the content of the submitted reports. In addition, some students conducted various negotiations not only based on the interests of their own country but also on the situation in other countries, and took action to lead an international coordination route. From this, it was shown that students could learn global issues in environmental and energy problems beyond the learning target through the application of this teaching material.

In the future, we will practice it for more students and conduct statistical evaluations such as questionnaire surveys. Additionally, in order to enrich the tutorial and to make it easier to utilize, we have been trying to embed the smart digital application called A-txt. A-txt [16] is the next generation educational system using AR technology [17]-[19] that links digital contents to diagrams and photographs printed on paper media or real things such as road sings and emergency exits, and extends them to digital books using common electronic portable terminals owned by users. Finally, we will discuss a method to spread it to nationwide KOSEN, such as extension to online type.

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INTRODUCTION OF ACTIVE LEARNING FOR ADVANCED CLASS STUDENTS THROUGH VISITING CLASS TO JUNIOR HIGH SCHOOLS

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Abstract

This report introduces an attempt for Advanced Engineering Course (AC) students to improve their cross-cutting skills. This is carried out in an experiment called "Experiment of Electronic and Computer Systems (EECS)" To appeal National Institute of Technology, Tsuyama College (Tsuyama KOSEN), the AC students visit junior high schools (JHS) and conduct a special class (visiting class: VC) for JHS students. The VC is performed mainly in southern part of Okayama prefecture, such as Okayama city and Kurashiki city, which account for about 80% of population in the prefecture because Tsuyama KOSEN is located in northern part of the prefecture and consequently JHS students and their teachers and parents living in southern part are not familiar with Tsuyama KOSEN. Moreover, more and more young students are not interested in science and technology. As a result, the number of applicants to Tsuyama KOSEN also has a tendency of decrease. It would be little doubt that the VC is effective to overcome such decrease. Objectives of the EECS are set improving not only technical skills but also those for communication, problem solving and teamwork abilities (so called "cross-cutting skills"), based on the model core curriculum advocated by National Institute of Technology, Japan. To improve the latter, the VC must be effective because AC students should cooperate with their colleges, communicate with JHS students and their colleagues, make schedules, and find and solve any problems in order to complete the VC. It is also used as criteria for the examination of accreditation by Japan Accreditation Board for Engineering Education. AC students should submit their weekly reports as well as final reports. The former includes peer-review to evaluate teamwork ability. They choose one out of three options, namely "MVP", "Acceptable" or "Failure", for other students. Results of AC student questionnaires show they have felt that their cross-cutting skills can be improved to a certain degree by conducting a VC. So, it can be said that the VC contributes to improve AC students' skills in above mentioned abilities.

Keywords: *visiting class, cross-cutting skills, teamwork ability, peer-review, active learning*

Introduction

It is well known that recent Japan's population is getting smaller and smaller and especially the number of young students decreases rapidly because of decline in birthrate [1]. In addition, more and more young students are losing their interest in science and technology in Japan [2]. As a result, the number of applicants to National Institute of Technology (NIT), Tsuyama College (Tsuyama KOSEN) also has a tendency of decrease. To overcome such decrease in applicants, it is little doubt that it is more effective to directly meet junior high school (JHS) students and promote Tsuyama KOSEN than to meet JHS teachers and appeal it to them.

Incidentally, Tsuyama KOSEN is located in northern part of Okayama prefecture, western part of Japan. The prefecture has about 80 % of its population in its southern part, such as Okayama city and Kurashiki city. The distance from Tsuyama KOSEN to such large cities is farther than 60 km. It is, therefore, important to appeal Tsuyama KOSEN to JHS students and their parents and teachers in such large cities because they are not familiar with Tsuyama KOSEN.

For this purpose, I have attempted to introduce visiting classes (VC) into a part of an experiment for Advanced Electronics and Information System Engineering Course (AC) students in Tsuyama KOSEN. The experiment is called "Experiment of Electronic and Computer Systems (EECS)". The VC is that the AC students visit JHSs in these cities and conduct a special class to appeal the school. Tsuyama KOSEN has conducted many such open lectures and visiting classes for JHS students and elementary school students so far [3]. However, most of them have been held near or in Tsuyama KOSEN, and there have been few such classes in southern part of the prefecture. Then, I have decided to introduce such visiting classes into the EECS, that the AC students visit JHSs in southern part of the prefecture, which has much more population than in the northern part. The visiting class must be designed to make the JHS students interested in science and engineering.

Objectives of the EECS to the AC students are set improving not only their skills for technology but also for communication, problem solving and teamwork abilities (so called "cross-cutting skills"), based on the model core curriculum (MCC) advocated by NIT [4]. To improve the latter (cross-cutting skills), the VC must be effective because, in order to successfully complete the VC, AC students should cooperate with their colleges, communicate with JHS students and their colleagues, make schedules, and find and solve any problems. It is also used as criteria for the examination of accreditation by Japan Accreditation Board for Engineering Education (JABEE) and for the evaluation by the National Institution for Academic Degrees and Quality Enhancement of Higher Education (NIAD-QE), Japan.

Materials and Pedagogy

Table 1 shows objectives of the EECS. Items marked with "*" are those for "cross-cutting skills required of engineers", which come from the MCC. The required achievement levels in teamwork ability, one of the cross-cutting skills, for AC students is "analysis level". This means that teams composed of members with diverse expertise can function smoothly and each member can act responsibly in a role-aware way to solve more practical problems. This advanced course consists of students from the fields of information and computer engineering and of electrical and electronic engineering. So, one of important objectives in this experiment is to develop the ability to successfully manage a team composed of students with different specialties. Students must meet these goals in order to earn credits for the EECS.

Though guidance, the AC students can be informed of the purpose of VCs, i.e. to appeal Tsuyama KOSEN, and that of the EECS listed in Table 1. They are also told to design a VC to suit these purposes. In response to these instructions, they design and schedule a VC and decide the theme of the VC based on what they want to convey to JHS students through the VC. Once the theme is decided, they then have to figure out the technologies required to realize the VC and to decide the person in charge (role of each person) suitable for the required technologies. For example, in the case of robot cars using microcomputers, they have to decide required tasks, such as what kind of microcomputer to use, what to do with programming, what to do with chassis and body, what to do with tires and motors, and how to control it, and then select appropriate personnel for each task. Next, they decide how much the teaching materials should be prepared while being aware of what they want to convey to JHS students. Since it is assumed that the class will be about one hour, they have to propose teaching materials that make JHS students feel a sense of accomplishment and are effective in education during that period. Since most of the AC students are new to VCs and such design seems to be the most difficult for them, advice from the instructor is essential.

As described above, the EECS aims at improving not only AC students' technical skills but also their communication skill and teamwork ability. These come from the MCC. However, it seems to be difficult to evaluate these abilities, so peer-review is introduced in their weekly reports to evaluate the teamwork ability. Such review is sometimes used in studies for technology education [5]. Table 2 shows items in the weekly reports. The first half is an implementation plan, implementation results, issues and reflections for schedule management. The latter half is the evaluation of teamwork ability, which is consisted of self-evaluation and mutual evaluation of collaborative work. They choose one out of three options, i.e., "MVP", "Acceptable" or "Failure", for other students. VCs are evaluated by taking a questionnaire to JHS students. In such questionnaires, the questioned person sometimes reads between the lines. So, we have evaluated it with taking that into account.

Table 1. Objectives of the EECS

1. Deepen basic knowledge on technology such as electronic circuits, control and networks.
2. The experimental results are summarized in a report using easy-to-understand diagrams and text.
3. Be able to systematically work on problem solving by demonstrating teamwork.*
4. Acquire design abilities such as the ability to clearly identify problems and find the most appropriate solutions and methods.*
5. Experiments can be carried out according to the schedule.*

Table 2 Items for weekly reports.

Today's goal: what you need to finish today's work.
Today's schedule: what will be elucidated, and to what extent and how will it be pursued today
Your role in the overall plan: what exactly you have to do and how much you must do according to the plan
What you did in today's class.
Impressions and reflections on myself today (from the viewpoint of collaborative working)
Self-evaluation of collaborative work (Choose one out of followings: "Excellent", "Acceptable", and "Failure")
Achievement level of tasks for the entire group (point deduction method from 100%)
If the overall group achievement is not 100%, why?

From the viewpoint of co-working, review other members: choose only one "MVP" from all members, the rests are reviewed with either "Acceptable" or "Failure".
Name of Student No.1:
Role of Student No.1: State the point briefly and concretely
Evaluation of Student No.1: "MVP", "Acceptable" or "Failure"
The reasons for the student No.1: "MVP"; why "MVP", why neither "Acceptable" nor "Failure"?: "Acceptable"; why "Acceptable", why neither "Failure" nor "MVP": "Failure"; why "Failure", why neither "Acceptable" nor "MVP"?

Results

Here are following two examples of VCs. One is making a remote control robot car and a soccer game using it. The other is making a metal detector and a treasure hunting game using it. In the former, a microcomputer and an RF wireless module are used. In the latter, two types of teaching materials, with and without a microcomputer, are designed.

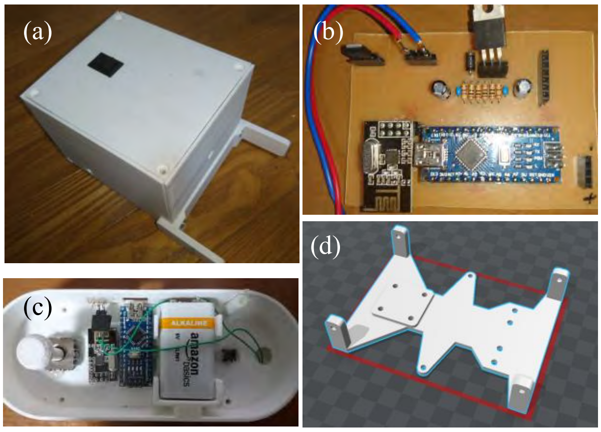


Figure 1. Photos of (a) main body, (b) control circut board, (c) remote controller, and (d) body part under design in 3D CAD.

The first example is as follows. We had JHS students make a remote-controlled robot car from a semi-finished one assembled by AC students in Tsuyama KOSEN in advance. An Arduino and an RF wireless module were equipped on both the robot car body and the controller. The robot car is designed and programmed so that the car moves in all directions when the joystick of the controller is operated. Printed circuit boards were designed by CAD and self-made by a processing machine. The main body and controller were designed with 3D CAD and self-made with a 3D printer. Figure 1 shows photos of (a) the main body, (b) the control circut board, (c) the remote controller, and (d) a body part under design in 3D CAD. These parts were designed, made and programed by the AC students.

The second one is as follows. We had also JHS students make a metal detector either with or without a micro-computer. The main circuit and the main body were also pre-fabricated by the AC students in Tsuyama KOSEN and what the JHS students do is to wind a wire on a bobbin to make an inductor coil. Before winding, they designed the coil, namely, diameter of the bobbin, winding number, thickness of the wire and so on. The quality of the coil determines the performance of the detector because the coil has very important role in the detector. In an analog system, if there is metal near the exploration coil, electromagnetic energy is taken by it and the voltage of the coil drops. The detector detects this voltage drop and then sounds the buzzer. In a digital system, the detector detects the change in frequency with and without metal. The amplitude and frequency of the AC signal applied to the exploration coil were designed using an electric circuit simulator, SPICE, but must be adjusted by repeating trial and error to make it easier to detect the metal by the AC students. Figure 2 shows photos of (a) printed circuit under design with CAD, (b) completed printed circuit board, (c) bobbin under design with 3D CAD, (d) metal detector in analog system, (e) metal detector in digital system, and (f) VC.

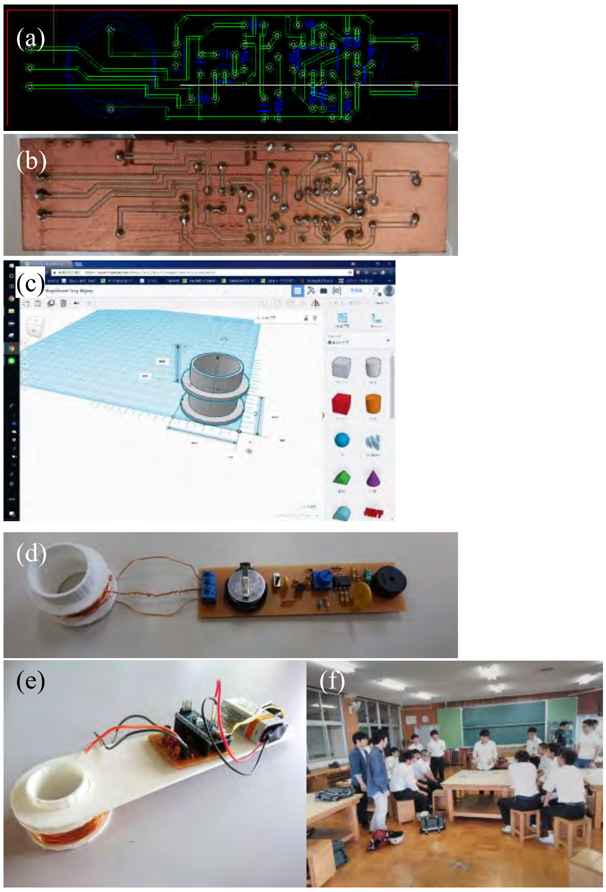


Figure 2. Photos of (a) printed circuit under design with CAD, (b) completed printed circuit board, (c) bobbin under design with 3D CAD, (d) metal detector in analog system, (e) metal detector in digital system, and (f) VC.

List 1 and Figure 3 show items and results of questionnaire to 132 JHS students. It is found that almost all students enjoyed the VC. About 60 % students are getting interested in Tsuyama KOSEN and 20 (15 %) students answered that they wanted to go to the school. Furthermore, 85 % answered to want to take other classes like this if there was an opportunity. These results indicate the VC is effective to appeal Tsuyama KOSEN to JHS students. List 2 shows some comments from the JHS students. These comments encourage the AC students.

List 1 Questionnaire items to JHS students.

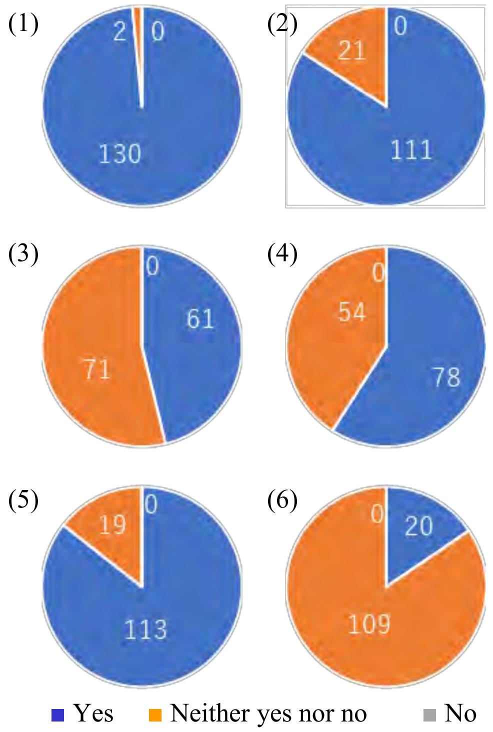
1. Do you enjoy the class?
2. Is the class easy for you to understand?
3. Can you take advantage of the class to your future student life?

4. Are you getting interested in Tsuyama KOSEN?
5. Do you want to go to Tsuyama KOSEN?
6. Do you want to take other classes like this one, again?

List 2 Comments in additional comments of the questionnaire from JHS students.

- I was surprised that the robots were made with a 3D printer.
- I was getting interested in machinery and Tsuyama KOSEN.
- I really enjoyed the class. Thank you.
- I wonder what should I do to make robots like this.
- It was difficult to operate the RF controlled robot.

Figure 3. Questionnaire results to JHS 132 students.



AC students should submit their weekly reports as well as final reports. The former includes peer-review to evaluate teamwork ability. They choose one out of three options, namely "MVP", "Acceptable" or "Failure", for other students. The "MVP" was set to 70 points, "Acceptable" to 50, and "Failure" to 0 points. The score for each student is totaled and averaged, and used as a reference for evaluation of his/her teamwork ability. The maximum score is 70 points. Table 3 shows an example of the weekly report. This group of three planed a VC that JHS students complete a semi-finished computer game console fabrication similer to the Gamebuino. In the example of the weekly report in Table 3, the evaluation student gives "MVP" to the evaluated student #1 and "Acceptable" to the student #2. The reason is that the student #1 made a suggestion and the student #2 persisted in the soldering. All of them work to help the team, but he evaluated that the the evaluated student #1 contributed more to the team than the student #2. Such evaluation was performed for each lesson. The scores of these three students were 61.0, 62.3, and 56.7, respectively. All of the menbers in this team worked hard, so no one rated other students "Failure" thoughout the experiment.

Table 3. Example of weekly reports (only for teamwork ability evaluation)

From the viewpoint of co-working, review other members
Student No.1 ·Role: To decide flow of the VC. ·Evaluation : "MVP" ·Reason(s): He proposed ideas.
Student No.2 ·Role: soldering ·Evaluation: "Acceptable" ·Reason(s): He was tenacious, thinking and trying to do a difficult soldering

Discussion

A questionnaire about cross-cutting skills is conducted to the AC students who experienced the VC. In the questionnaire, each item was evaluated on a scale of 5 with 5 being very improved, 4 being moderately improved, 3 being slightly improved, 2 being no change, and 1 being deteriorated. Each questionnaire item is defined as follows.

1. Teamwork ability; the abilities to properly assign roles to each member and to pass through the assigned roles.
2. Communication skills; information sharing, information transmission, information reception (how much information to share with whom, timing).
3. Problem-finding ability; the ability to find factors to obstruct to go on next stage.
4. Problem-solving skills; the ability to think and act to solve problems.
5. Scheduling ability; the ability to make a schedule and execute as it is.

Table 4. Questionnaire items and results for AC students

Item	Average	Standard deviation
1.Teamwork ability	4.00	0.00
2. Communication skills	4.11	0.82
3. Problem-finding ability	3.89	0.82
4. Problem-solving skills	3.78	1.07
5. Scheduling ability	3.44	0.53
Average	3.84	0.65

Table 4 shows the questionnaire items and averages and standard deviations of the results. The overall average and the standard deviation are 3.84 and 0.65, respectively. The best and worst items are items #2 and #5, respectively. This indicate that the students feel much improvement of communication skills but they are not good at scheduling. Surprisingly, all students answered 4 for the teamwork ability, so standard deviation is zero. For item #4, there is a large standard deviation. This means that some students have gained confidence a lot while others do not. Students with much confidence feel that they have increased their problem-solving ability by contributing ideas to the team. On the other hand, students with little confidence cannot do the same. Consequently, the gap between them is growing. Even in such cases, the latter feels that they have improved their teamwork skills, as shown in the result for the item #1. The questionnaire is also asking them what is important to work in a team. Their comments are as follows;

- The important thing is not to just stick to your own opinion, but to listen to the opinions of others and to reconcile each other's opinions.
- Communication is the most important. If you are in trouble, ask other members and you may solve the problem.
- To progress a project smoothly, to assign each member the role in the project and to confirm the progression of member's task each other are important.

In the end, they have concluded that the most important is to communicate each other, as expected.

Conclusions

In conclusion, in this paper, an attempt in order to improve the cross-cutting skills for advanced course (AC) students has been reported. The AC students visit junior high schools (JHS) in southern part of Okayama prefecture, where has large population, and conduct a special class (visiting class: VC). A part of the objectives of the attempt is to improve their skills for teamwork and communication abilities. Two examples of VCs are introduced. The questionnaire results to JHS students have indicated that such classes are sufficiently effective to appeal Tsuyama KOSEN. The JHS students seem to enjoy the class. To evaluate teamwork ability, peer-review is introduced. Students evaluate mutually their teamwork ability each other from the view point of collaborative working. The results of the review by students have little contradiction to that by me, so the review seems to be performed properly. The result of the questionnaire to the AC students shows the VC contributes to improve their skills for the teamwork ability to a certain degree. However, they haven't felt improved skills for scheduling. It must be future work.

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Utilizing ICT in a Practical Lecture of Information Literacy for First-Year Students at Anan KOSEN

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Abstract

This paper demonstrates a teaching method for a practical lecture on Information Literacy conducted for first-year students at Anan KOSEN. Studying information literacy is important for students in becoming competent engineers. In the practical lecture presented in this paper, the key aspects consist of a teaching method involving a flipped classroom and effectively utilizing applications that include a learning management system (LMS) and a specialized interactive video system called a Response Collector (RC), which records all the operations performed by students. The practical lecture is composed of 30 classes taught to 160 students over one year, with two classes of 80 students held each week. In the first semester, students learn the usage of Microsoft Office; in the second semester, they learn about computer basics, information network and security, programming, and so on. In the flipped classroom, students study the contents of the Information Literacy course in advance, such as lecture slides and videos on the LMS and RC, before attending face-to-face classes. Usually, teachers worry about how students watch the video. Based on the data collected by the RC, teachers can check the detailed watching history of each student and investigate their watching behavior. It is important to make students watch the video seriously. As preparation for the face-to-face class, students are assigned to summarize the lecture contents and prepare their own notes to help them fully understand the contents. At the beginning of the face-to-face class, students answer questions provided by the LMS, where they are allowed to refer to their individual notes. During the face-to-face class, the 80 students are divided into 20 groups and are given practical assignments that include summarizing the lecture contents in MS Word, completing quizzes to upload to the LMS, and using the Internet for research to deepen their knowledge regarding the material they have studied during their preparation. The assignments can be submitted via the LMS. In this paper, we demonstrate the use of the LMS and RC combined with a flipped classroom to effectively conduct a practical lecture of Information Literacy to a class of 80 students.

Keywords: *Flipped Classroom, Response Collector, LMS, Information Literacy, Engineering Education*

Introduction

KOSEN is the abbreviation of *Koutou Senmon Gakkou*, which literally means “high-grade” (*Koutou*) “specialty” (*Senmon*) “school” (*Gakkou*). KOSEN fosters students junior high school graduates to be practical engineers through a five-year engineering education in Japan. For KOSEN students, studying information literacy is very important in becoming competent engineers who can be active in a global society. That is because every field needs those skills to create and develop novel products by using ICT tools and communicating with people in companies. Particularly, in the information society, engineers need the skills to select important information from a large mass of information and utilize it to generate new ideas and develop products. In Anan KOSEN, Information Literacy is a compulsory subject for first-year students. They primally study Liberal Arts and common engineering subjects including Manufacturing Engineering, Basic Engineering Design and Information Literacy. In this regard, Information Literacy is one of the important subjects to educate students who just started learning in KOSEN.

We designed the Information Literacy lecture as a practical lecture so that students can actively study this subject. To use the time of the practical lecture effectively for students to work in groups by using computers, a flipped classroom was adopted as the structure of the classroom [1][2]. In the flipped classroom, students study the contents of the Information Literacy course in advance, such as lecture slides and videos, on a learning management system (LMS) and a specialized interactive video system called a Response Collector (RC). In this paper, we first introduce the flipped classroom with the LMS and RC applied for a practical lecture of Information Literacy; we then illustrate some examples of how students study in the classroom.

Structure of Information Literacy course with flipped classroom

The Information Literacy course for the first-year students in Anan KOSEN is composed of 30 classes taught to 160 students over one year, with two classes of 80 students held each week. In the first semester, students learn the usage of Microsoft Office; in the second semester, they learn about computer basics, information network and security, programming, and also they practice using Microsoft Office by working in groups. The author is in charge of the course in the second semester, which has 16 weeks for the course including the midterm and the final examinations.

Table 1 shows the schedule of the Information Literacy in the second semester. Since the lecturer and structure of the classroom change from the first semester to the second semester, the first face-to-face classroom in the second semester is conducted as an orientation in which classroom proceedings are explained and a team-building activity is conducted. In the team-building activity, students first make their name card in view of their special skills, features, and food preference. Then, after making groups, they introduce themselves to the other group members with reference to their cards. After the team-building activity, the lecturer collects their cards, which are used to record their effort in the following 13 classes, except for the examinations.

As the structure of the Information Literacy course, the flipped classroom was adopted. In the flipped classroom, students study the contents of the Information Literacy course in advance, such as lecture slides and videos, on the LMS and RC before attending the face-to-face class. As for assignments, students summarize the contents on their notebook before attending the face-to-face class.

At the beginning of the face-to-face classroom, the duration of which is 90 minutes, students complete 15-minute mini quizzes on the LMS to confirm their understanding of the lecture contents. Students are allowed to refer to their individual notebook when answering the quizzes. By the function of LMS, students can check the their score as soon as they answered the quiz.

After completing the quizzes, the lecturer explains the contents of the practical exercises and assignments in about 15 minutes. In the last 60 minutes, students work on the assignments in their group by using LMS. Each

Table 1. Schedule of the Information Literacy course in the second semester

Week	Content
1	Orientation and team-building
2	How the computer works 01: about software
3	How the computer works 02: about hardware
4	Information retrieval and Web
5	Analog and digital
6	Digitalization of information
7	Various services on the Internet
8	Midterm Examination
9	User interface and usability
10	Information society and the problems
11	Information security
12	Algorithm and programming 01
13	Algorithm and programming 02
14	Exercise 01
15	Exercise 02
16	Final Examination

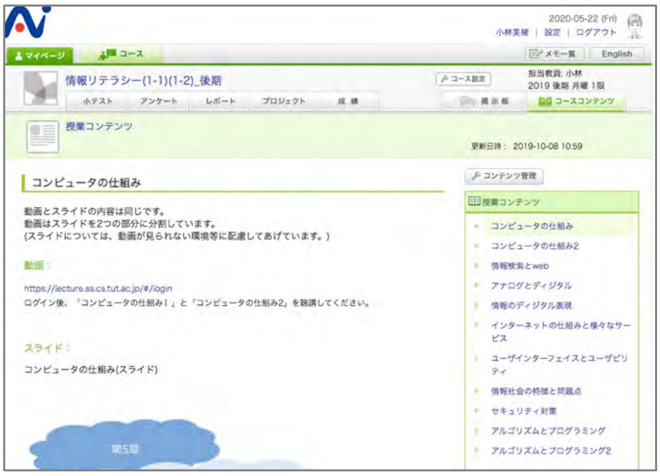


Figure 1. Captured image of LMS, *Manaba*

group consists of about four students. In a practical lecture, the 80 students are divided into 20 groups, separated into two computer rooms. To make enough time for students to actively use computers and discuss the topic in the group, we reduced the time for the lecturer's explanation.

Utilizing LMS and RC

As the ICT tools, the LMS and RC were utilized in the Information Literacy classroom. Figure 1 shows the captured image of the LMS named *Manaba, Asahi Net, Inc., Japan*. *Manaba* has various functions for teachers to manage lecture contents, such as providing quizzes, distributing and collecting assignments, presenting lecture slides, managing group projects, and so on. The LMS has not only the functions of providing lecture contents and quizzes, but also students can communicate via the project page on *Manaba* so that they can effectively work on the group assignments.

Manaba also has the function to record the browsing history of each student so that teachers can know when each student accessed to the lecture contents. As for the video distribution, which can be embedded in the page on the LMS by using *YouTube*, teachers can know whether or not the student accessed the page on which the lecture videos are shown, but teachers cannot know *how* students studied and watched the lecture videos. Usually, teachers are worried about how students watch the video because it is very important for students to watch lecture videos seriously, especially in a flipped classroom.

To cover this point, we used RC instead of distributing lecture videos via *YouTube* by just embedding in the page on *Manaba.* The RC was developed by the collaborative research between the Umemura Lab., Toyohashi University of Technology, Japan and TwoGate inc., Japan [3]. The RC also uses *YouTube* to distribute the lecture videos, and it provides an interactive interface that has functions to record responses from students and their watching behavior. In the Information Literacy course, when students study as in the flipped classroom, students must access to *Manaba,* before logging into the RC from the hyperlink of the RC presented on *Manaba*. Figure 2 shows the page flow of students to use RC.

Figure 3 shows the captured image of the RC. The RC can be shown via a web browser. The RC presents the lecture video on the left-hand side, and a set of buttons consisting of a play, fast-forward, and rewind button is shown at the upper right, whereas the response buttons are displayed just below it. The response buttons are displayed while students are watching the video, and they can push the buttons when they feel they have come across something interesting, important, and/or difficult, of if they had questions about the contents of the video.

The RC can generate diagrams of the aggregation related to the watching behavior of students. The upper and the lower diagrams shown in Fig. 4 present a heat map chart corresponding to the number of views of the video and the number of times the response buttons were pushed by students, respectively. The horizontal axis denotes the timeline of the video indicated by seconds. In the heat map chart, the color bar, from blue to red, denotes the number of the views, from zero to six, in this video. Based on the heat map chart, a teacher can know which student watched the video well, and the teacher can investigate certain time-points or parts in the video that students repeatedly watched. In the diagram below in Fig. 4, the curves denote the number of times each response button was pushed. The diagram shows that about 10 students felt interested at the beginning of the video, and after 150 seconds passed, nine students pushed the button corresponding to importance. The teacher can know the trend of the feeling of students even in the flipped classroom by the RC.

Figure 2 Page flow of students to use RC

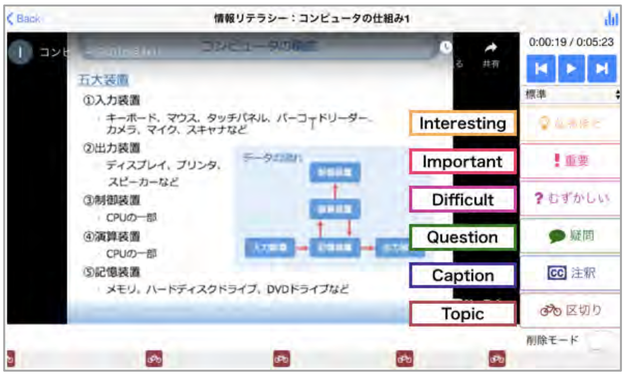


Figure 3 Captured image of Response Collector

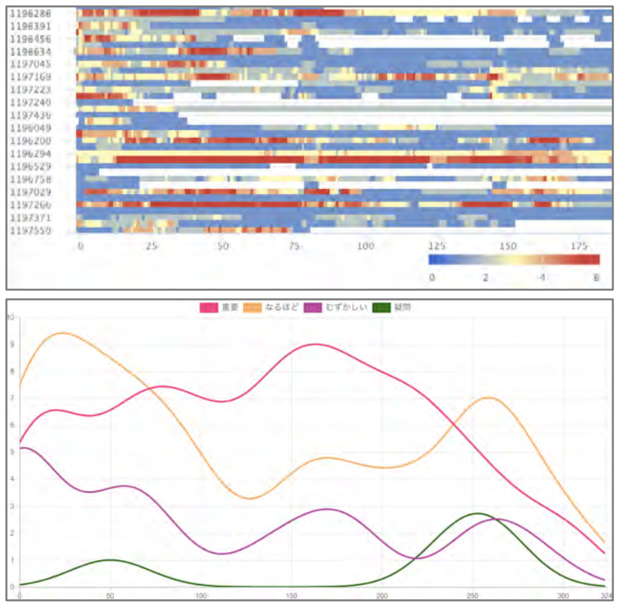
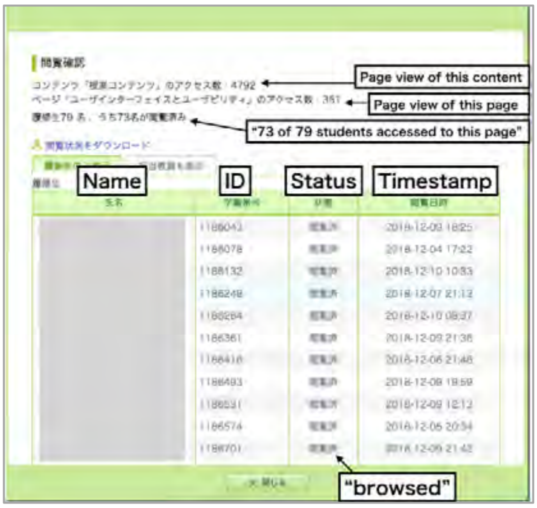


Figure 4. Display of aggregation

What teachers can obtain about watching behaviour of students by *Manaba* and RC

In this section, we focus on what teachers can obtain about the studying behaviour of students by using LMS and RC. Basically, both methods use *YouTube* as a video

(a) Page showing lecture video



(b) List for browsing history

Figure 5. Pages of lecture video and browsing history on *Manaba*

distribution system, so teachers first upload the lecture videos to *YouTube.*

1) *Manaba*

When teachers present their videos on *Manaba*, they embed the video, and the system can show the video on the site. Figure 5 shows the pages of the lecture video and the browsing history on *Manaba*. The system can record the browsing history of students including the timestamp. The teachers can know which students accessed the page from the display of the status on this page. Furthermore, the display of the status can show whether or not students visited the page again after the page is updated. However, teachers cannot know whether the students actually watched the video or not because the display of the status changes by the timestamp when the student visited the page and not by the timing of watching videos. Even when students actually watch the videos, it is difficult for teachers to know which part of the video students feel difficult to understand because *Manaba* has no such recording function.

2) Response Collector

To watch the lecture videos via the RC, students first access to *Manaba* and then log into the RC as shown in Fig. 2. According to the information about students' interactions with the response buttons while watching the video, teachers can identify the points that students felt were interesting, important, difficult, and/or question-worthy. The RC can tell teachers how students watched the lecture video. In Fig. 6, the bottom panel shows the diagram of the responses from students. When a teacher clicks at the peak of the curve, "Difficult," the corresponding scene of the video is shown in the upper panel, thus allowing the teacher to know the point(s) indicated by students. The information is very effective in allowing teachers to elucidate certain points, based on students' response-button indications, in the face-to-face

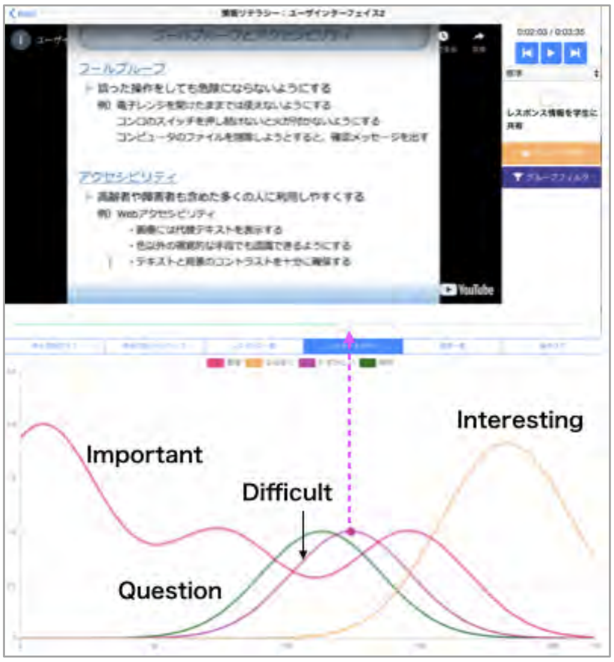
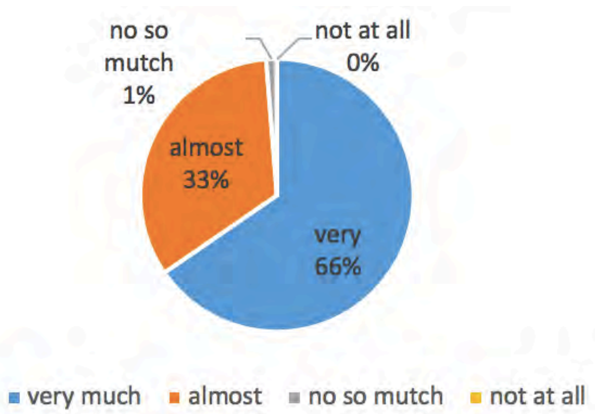
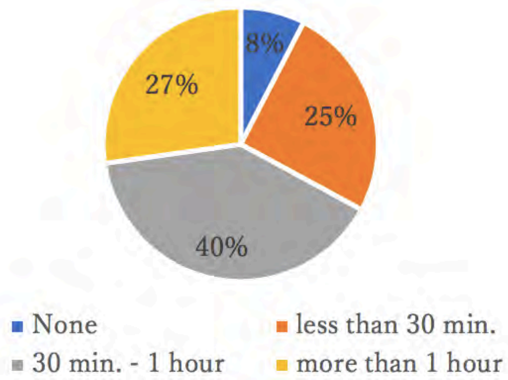


Figure 6. Teachers can know the points at which students perceived difficulty by the RC

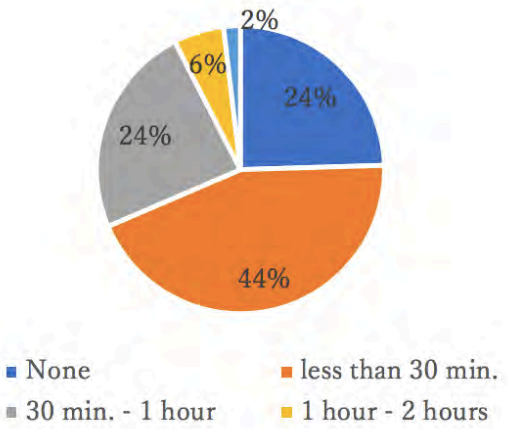
Figure 7. Students working on group assignments



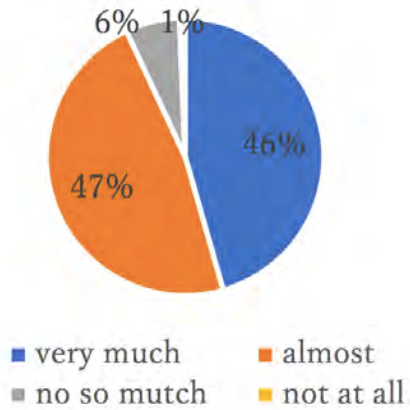
(a) Attitute in the class:serious or not



(b) Duration for avarage prepaation



(c) Duration for average review



(d) Satisfaction with the course

Figure 8. Survey results

class. Teachers can then improve and update the lecture videos accordingly.

Results of survey after final examination

In face-to-face classes, students can use one desktop computer per person. Figure 7 shows the situation where students work on their group assignments in the face-to-face classes. After finishing the final examination of the Information Literacy course, the survey to investigate the achievement of students was conducted. Figure 8 shows the results of the survey. In students' self-evaluation on their classroom attitudes, 99% of students answered that they studied very or semi-seriously in the classroom. Regarding the duration of their preparation for the face-to-face class in the flipped classroom, 67% of students studied longer than 30 minutes, but 8% of students did not study at all. As for the reviewing of the topic of the Information Literacy course, 68% of students did not review the contents at all. However, more than 90% of students were satisfied with the Information Literacy course.

From the records collected by the RC, there is a negative correlation between the number of students who watched the lecture video and the number of times classes were conducted. Without the RC, we cannot notice this fact. In fact, the ratio of students who watched the video was about 35% at the first flipped classroom. This was not the result we expected. However, more than 67% of students answered that they studied for at least 30 minutes in preparation. The investigation suggests that most students studied with the lecture slides uploaded on the LMS instead of watching lecture videos. Students preferred to study with the lecture slides because summarized scripts corresponding to the topic in a lecture video was also provided on the LMS. As for the low ratio of students who watched the lecture video, we considered two reasons. One is because most of the contents in the video consisted of knowledge about the Information Literacy, so that students could understand the contents without watching the lecture videos; the other is that studying with lecture videos is troublesome for students rather than using the lecture slides documents. The detailed investigation would be carried out in the future.

Conclusions

In this paper, we introduced a practical lecture on the Information Literacy course for the first-year students in Anan KOSEN. We adopted the flipped classroom for the course, and as the ICT tools, LMS and RC were applied to the lecture. As the LMS, we used *Manaba*, which can manage the flipped classroom. The LMS has the function to record the timestamps of the browsing history to determine when students accessed the page. However, based on the information, teachers cannot know *how* students watched the video. Therefore, we used the RC together with the LMS. The results obtained from the RC showed that the ratio of students who watched the lecture video was not very high. However, most students study in advance for face-to-face classes. Accordingly, it was found that most students studied with the lecture slides presented on the LMS instead of watching the lecture video through the RC. To make more students watch the lecture videos seriously, the contents of the lecture video have to be improved.

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A PBL-ORIENTED ENGLISH CLASS TO FOSTER GLOBALLY COMPETENT FUTURE ENGINEERS

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Abstract

The world today has drastically been changing. Due to the rapid change, it is considerably difficult to predict what the future world will be like. Global issues such as climate change, racial conflict, and economic disparity must be tackled by all the countries. Under such a social situation, the UN's 17 Sustainable Development Goals (SDGs) are attracting lots of attention in the field of education. Students are required to obtain the abilities to solve global issues which nobody has ever confronted. Teachers are forced to change their teaching style from cramming knowledge in students' heads to facilitating students' autonomous learning. Since the fall semester in 2019, our school has started a new educational project to nurture globally competent future engineers. In this project, four writing classes taught by Japanese teachers are being removed. Instead, five new classes by native English speakers are being introduced. This semester we began to provide one of the five classes, which was named "Practical English Exercises for Engineering." Although some expressions of technical English are taught in the class, it essentially focuses on Project-Based Learning (PBL). For instance, the students who took this course participated in the excursion to Matsue Castle and guided international students in English around the inside of the castle. Then, they were divided into six groups, each of which had five members and worked on a small project related to SDGs such as gender equality, clean energy, and recycling food. In order to measure the students' global competences, we have made our own questionnaire by reference to the PISA 2018 questionnaire. Our questionnaire asks the students to answer 20 questions in terms of knowledge, cognitive skills, attitudes, and values. For each item, the respondent has to choose one of the five numbered Likert-scale options and the maximal number, 5, indicates the most preferable response. As a result, the response averaged over the 20 questions was 4.168, which seems to be relatively high although no comparable data are available.

Keywords: *future engineers, global competences, the sustainable development goals, project-based learning*

Introduction

Our school, Matsue College, is one of the 51 National Institutes of Technology in Japan, which are categorized into a higher education institution of science and technology in the Japanese educational system. This institution offers a 5-year course and the age of the students ranges from 15 to 20. Most of them will work as engineers and the graduates' performance is highly rated in the industrial world. However, their English proficiency is not very high compared to university students. For example, the average TOEIC score of the fourth graders in 2018 was lower than that of Japanese university students (approximately 570). There may be several reasons for this. First of all, most students are more interested in mathematics and science than English. Also, as they become higher graders, the number of English classes decreases because they have to learn more expertise relevant to their major fields. The most problematic aspect would be in the fact that the English curriculum of our school has been biased toward grammar and the memorization of words and idioms (Hattori et al., 2016). As a result, the students' motivation to learn English seems to be significantly low. Although most of the Japanese teachers understand the importance of improving their communicative skills, the way to teach English may not be so different from what it used to be. To change this situation, a new English class entitled "Practical English Exercises for Engineering" has started since the fall semester in the fiscal year 2019. This class focuses on Project-Based Learning (PBL), which is different from traditional instruction. PBL is defined as "an instructional approach that contextualizes learning by presenting learners with problems to solve or products to develop" (Moss and Van Duzer, 1998). The qualitative and quantitative research by Simpson (2011) showed that PBL had a significant effect on the language development of the low and medium ability groups of students. She also reported that the high ability students had shown progress in speaking and writing, but not for their listening and reading skills. Othman and Shah (2013) stated that the students instructed in the PBL setting had shown greater development in their writing skill, especially in terms of the organization and content of their essay. On the other hand, Azman and Shin (2012) demonstrated that the students' reading and speaking skills had been improved by the PBL approach in

English for a second language classroom. Accordingly, it seems to be difficult to clarify which skill can be effectively developed through PBL among the four basic skills of English (i.e. reading, listening, speaking, and writing). However, the earlier studies shared a similar conclusion where PBL approach could boost students' motivation, enhance their self-confidence, and facilitate development of their generic skills such as communication and critical thinking skills (Azman and Shin, 2012; Poonpon, 2017; Ayu Sukerti and Yuliantini, 2018; Lin, 2015). From the findings mentioned above, a PBL approach has been adopted in our new class. This paper aims to report the materials and methods in the context of teaching in an EFL classroom and the results of a questionnaire survey conducted to assess the global competences of the participants.

Materials and Methods

Practical English Exercises for Engineering is a PBL-oriented English class for the third graders and held in each fall semester. Among those who are interested in this class, only 30 third graders were allowed to participate by lottery. They are 3 from mechanical engineering course, 8 from electrical engineering, 8 from control engineering, 4 from information engineering, and 7 from civil engineering. The grading of the course relies on four scores: attendance and in-class participation (20%), four short tests (20%), final presentation (40%), which is broken down into teacher evaluation of 30% and student evaluation of 10%, and final report (20%). If their final grading score is greater than or equal to 50 points, the students will earn one credit. The course consists of 15 weekly lessons and is

Table 1 Lesson Plan and What Is Taught Every Week

Week	Lesson title	Contents of each week
1	Course outline, introduction to the contents of the class, self-introductions	Self-introductions, ice breaker, making groups, creating ***an original product (a pen case)***.
2	Engineering design process, ***mini group project***, introduction to Ohm's law	Studying the engineering design process and learn key expressions, create ***a pen case*** by following the design process, learn key expressions for studying Ohm's law.
3	Short test 1, ***short presentation of product*** from Week 2, lesson about Ohm's law	The short test will cover vocabulary and main ideas from the previous class. Students will read and work to understand a short text describing Ohm's law, and then work together to practice explaining it in English.
4	Explaining descriptive adjectives, lesson about digital circuits, explanation about trip to Matsue Castle	Students will learn descriptive adjectives related to engineering (curved, hexagonal, etc). Students will study a short text about digital circuits. There will be a short explanation about excursion to Matsue Castle.
5	Short test 2, lesson on phrasal verbs, prepare for excursion to Matsue Castle	The short test will cover vocabulary and main ideas learned in the previous class as well as a short lesson on phrasal verbs for engineering (put on, carry out, etc). In groups, students will prepare for ***excursion to Matsue Castle***.
6, 7	***Group excursion to Matsue Castle***	***Students will guide exchange students through Matsue Castle***, using English to communicate information.
8	Presentation by Teaching Assistants (TA) about home country, Introduction to PBL, SDGs and related themes, decide groups	A TA will make a short presentation about a problem affecting their home country. Then, there will be an introduction about SDGs, PBL and deciding group members and theme.
9	Lesson on PowerPoint presentations, ***project group work***	This class will teach the basics of making a presentation. Students will work on ***final projects***.
10	Short test 3, ***PBL group work***	Students will work in groups to discuss ***their project***.
11	Short test 4, ***PBL group work***	The short test will cover material from the previous class. Students will work on ***their final project***.
12, 13	Lesson on public speaking, ***preparation for final presentation***	Students will receive guidance for making the final presentation. Then students will prepare ***their project*** during the remaining time.
14	***Preparation for final presentation***	Students will rehearse and prepare for ***their final presentation***.
15	***Final presentation day***	Students will make ***a final presentation*** as a group. The deadline for papers on their project will be announced on this day.

instructed in a team-teaching manner by five teachers: 2 native English speakers and 3 non-native English speakers. Table 1 indicates the lesson plan and what is taught every week.

In Weeks 3 and 4, the students read short texts describing Ohm's law and digital circuits, and learned technical terms in the filed of electrical engineering. Since the course aims to cultivate the students' practical communication skills, it also encourages them to work in group activities as much as possible. For instance, from Week 1 through 3, the students put together their original pen cases in groups of five and described their features and sales points in English. In order to create a pen case, clothes hangers and cardboard were given to each group. Figure 1 demonstrates an example of the pen cases which the students invented.

Fig. 1 An example of the pen cases invented by the students.

Fig. 2 Exterior of Matsue Castle.

In Weeks 6 and 7, the students went to Matsue Castle, which is designated as a national treasure of Japan, and guided eight international students in English around the inside of the castle. In the previous class (i.e. Week 5), we had the students think about what and how they explain in the castle watchtower. Figure 2 shows the exterior of Matsue Castle Tower. It was constructed in 1611 and consists of five stories and a basement. On each floor, material remains such as arms and helmets are exhibited. The eight students above consist of four exchange students from Temasek Polytechnic of Singapore and four international students of Shimane University. One of the authors teaches English at Shimane University too and invited the four students to the excursion.

In the latter half of this course, the students learned about the UN's 17 Sustainable Development Goals (SDGs) and how to make an effective presentation in English. In Week 8, a teaching assistant (TA), who came from India, presented a social problem in her country and the five teachers proposed six distinct projects related to SDGs:

- Recycling Food,
- Gender Equality,
- Shredded Paper,
- Rocket Stove,
- Plastic Waste,
- Clean Energy.

Each teacher took charge of at least one project and helped the students work on his/her project. The students were shuffled and divided into six groups of five, so the group members were different from those in the excursion to Matsue Castle.

In the Recycling Food project, the students went to Lake Nakaumi located in the north-eastern part of Shimane prefecture and gathered the edible seaweed, "Ogonori" with a rake, boarding on a small ship. In order to make this activity successful, the non-profit organization, Nature Restoration Center greatly helped the students and teachers. Then, the collected seaweed was scattered in a field where soybeans are grown. Getting through this process, the students deeply understand how food is recycled.

In the Gender Equality project, the students did a questionnaire survey toward the second graders in our school. After that, they found out what kind of gender gap exists in the school by analyzing the results of the survey.

The group working on the Shredded Paper project collected shredded paper from the teachers' offices. Then, they compressed the paper and changed it into pellets as fuel for a rocket stove. The group members of the Rocket Stove project designed their original stove (see Fig. 3) and burned the pellets in it. The two projects above were supported by an associate professor at the Department of Mechanical Engineering.

Fig. 3 Snapshot of the rocket stove.

The students dealing with the Plastic Waste project did some researches on how to reduce plastic waste and then described how much of the waste is recycled in Japan. Due to the time limitation of the teacher who led the group, most of their activities come from searching on the Internet.

Finally, the Clean Energy project group developed a condenser with ocean waster (i.e. salty water) and used it as a battery which is connected to a solar panel. They attempted to charge a smartphone by using their solar battery system and then showed a short movie on the charging process in the final presentation. An aid by a professor at the Department of Electrical Engineering and Computer Science was indispensable to do this activity.

In Week 15, all the groups made a 5-minute presentation in English about the outcomes of their projects. The teachers asked each group at least one question in English and evaluated their presentations in terms of six items: (1) what the presenters want to say is intelligible, (2) the organization of the PowerPoint slides is good, (3) the presenters gave a talk in a loud voice and at an appropriate pace, (4) the pronunciation and intonation of their English are good, (5) English expressions used in figures and tables are easy to understand, and (6) the presenters properly answered questions in English. The grading score of the final presentation also includes the students' peer reviews based on a scoring rubric and assessment of a one-page report on their project.

Results and Discussion

The new class provided the students with the opportunities to participate in a mini group project, the excursion to Matsue Castle, and the presentation on a project related to SDGs. In order to evaluate how effective the PBL approach is, we asked the students to write feedback comments on the excursion and respond to a questionnaire on global competences. The results of analyzing their feedbacks and responses will be discussed in the following parts.

First, most of the students' feedback comments were quite positive, so it can be said that they really enjoyed the excursion. For a more objective analysis, a text mining tool, KH Coder (Higuchi, 2014) was applied and then frequently co-occurred Japanese words are shown as a network in Fig. 4. The number of paragraphs used in this analysis is 24. Each paragraph corresponds to the feedback of each student. Two words which collocate with each other within the same paragraph are connected with an edge in the network. The four nodes in pink indicate high betweenness centrality. The size of a node is proportional to the frequency of the word it represents. That is, the higher a word frequency is, the larger the node size becomes. The total number of

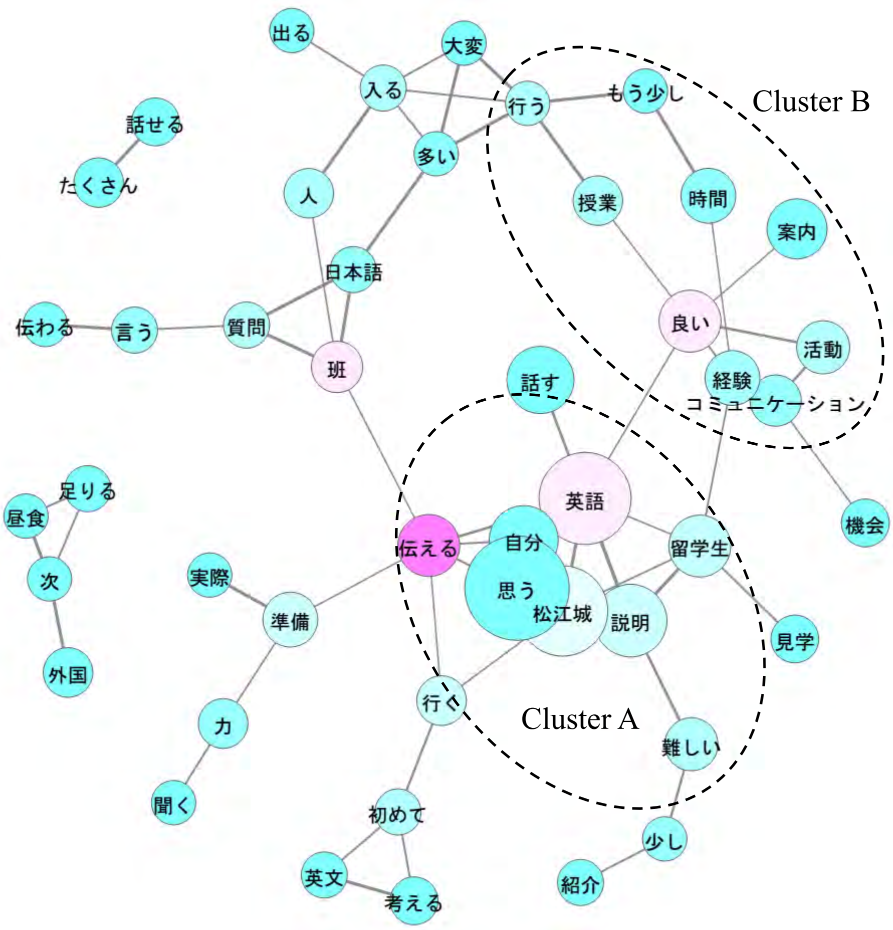

Fig. 4 A co-occurrence network of the words in the feedback comments written by the students.

words is 2,391.

The Japanese words in Cluster A are 伝える (tell), 自分 (self), 思う (think), 英語 (English), 松江城 (Matsue Castle), 説明 (explanation), 留学生 (international student), and 難しい (difficult). This cluster implies that the students found it difficult to explain Matsue Castle to international students in English and to tell them what they thought. On the other hand, Cluster B includes words such as 行う (do), もう少し (a little more), 時間 (time), 授業 (class), 案内 (guidance), 良い (good), 活動 (activity), 経験 (experience), and コミュニケーション (communication). Thus, this cluster suggests that the students regarded the excursion as a good activity to experience English communication although they required more time to do it. The time may also include the one to prepare for the excursion during the class. In fact, the students had only one week before the excursion and the teachers did not offer them enough information about Matsue Castle. It would be better to pass them an English brochure of the castle and give them some instruction on vocabulary prior to the excursion. For this purpose, at least two weeks should be necessary.

Next, we made our own questionnaire by reference to the PISA 2018 student questionnaire (OECD, 2018). In this questionnaire, the students were asked to answer 20 questions shown in Table 2. According to OECD, global competences can be measured by four dimensions: knowledge, cognitive skills, attitudes, and values. The questionnaire offers five questions for each dimension. Each of the 20 questions has five numbered Likert-scale choices: (1) not at all like me, (2) not much like me, (3) somewhat like me, (4) mostly like me, and (5) very much like me. The larger the number of choice is, the more preferable the response becomes. This means that globally competent respondents tend to have a greater number for each item.

Of the results for the 20 questions, the most remarkable ones are shown in the form of pie chart in Fig. 5. The pie chart for Question 4 indicates that 40% of the students did not gain enough knowledge to apply

Table 2 Twenty Questions to Measure Students' Global Competences

Targeted global competence	No.	Question
Knowledge	1	I learned new information about SDGs.
	2	I learned new English expressions related to engineering.
	3	I learned new information about global issues.
	4	I learned new ways to apply SDGs to my own life.
	5	I noticed communicative differences between people from various countries.
Cognitive skills	6	I improved my oral communication skills in practical situations.
	7	If there is a problem of communication with people from other cultures, I find ways around it (e.g. by using gestures, re-explaining, writing etc.).
	8	When I communicate with people from other cultures, I frequently check that we are understanding each other correctly.
	9	I give concrete examples to explain my ideas.
	10	I am capable of overcoming my difficulties in interacting with people from other cultures.
Attitudes	11	I want to learn more about SDGs.
	12	I want to use my engineering skills to solve problems.
	13	I want to improve my communication skills with people from other countries.
	14	I reduce the energy I use at home (e.g. by turning the heating down or turning the air conditioning up or down or by turning off the lights when leaving a room) to protect the environment.
	15	I am interested in how people from various cultures see the world.
Values	16	I think that SDGs are important things for engineers to solve.
	17	I respect the values of people from different cultures.
	18	I value the opinions of people from different cultures.
	19	I think that studying English is important for my future.
	20	I want to learn how people live in different countries.

the concepts of SDGs to their daily lives. It might be necessary for the teachers to provide a clue to combine what they learned in class to their surroundings. For Question 8, approximately 37% of the students chose the neutral choice (i.e. somewhat like me). This means that their communication skills have some room to improve in global contexts. For Question 10, the ratio of respondents to the four choices (i.e. numbers 2, 3, 4, and 5) are the same percent of 23.33. In addition, there was a student who was not able to choose any choice. It is possible that the meaning of "overcoming my difficulties" is unclear to the student. Thus, Question 10 should be given along with concrete examples in the future questionnaire. The pie chart for Question 12 demonstrates that more than 60% of the students are enthusiastic about contributing to solving global issues as engineers. This is the attitude that we want our students to obtain via the new English class. The attitude also seems to have affected the result for Question 16. Namely, more than 90% of the students understand how important realizing SDGs is for global engineers. Unlike other English classes in our curriculum, the new class offered the students more opportunities to study with international students. At times, there was even an atmosphere where the author felt as if he had been in a foreign country.

The response averaged over the 20 questions and the 30 students was 4.168. In order to check if this mean score is statistically significant, the mean score for students who do not take this course (i.e. the sample mean of a control group) is necessary. On the Web site of OECD, however, no comparable data are available. To carry out hypothesis testing, we are planning to do the same questionnaire survey before and after students' learning in the PBL setting.

Conclusion

As a new attempt to nurture globally competent future engineers, a PBL-oriented English class has started for 30 selected third graders. It contains three project-based activities: inventing an original pen case, the excursion to Matsue Castle, and group work related to SDGs. This course was taught by five teachers: two native English speakers and three non-native English speakers. Two teaching assistants from India and Senegal also supported the instruction in the PBL setting. Moreover, four exchange students from Singapore attended most of the classes. Such in-class diversity appears to stimulate the students' motivation. That is, the students seem to have understood the reason why they study English. Their changes in attitudes and values have been confirmed through a questionnaire survey on global competences. Their positive feedbacks have proved that the PBL approach is effective to foster the global competences to some extent, however, the weight to teaching technical English should be reconsidered. In fact, one quarter of the students who took this course feel that they did not learn much vocabulary related to engineering. Therefore, the future work will be to maintain the balance between the student-centered learning through PBL and the teacher-centered instruction on vocabulary.

Acknowledgments

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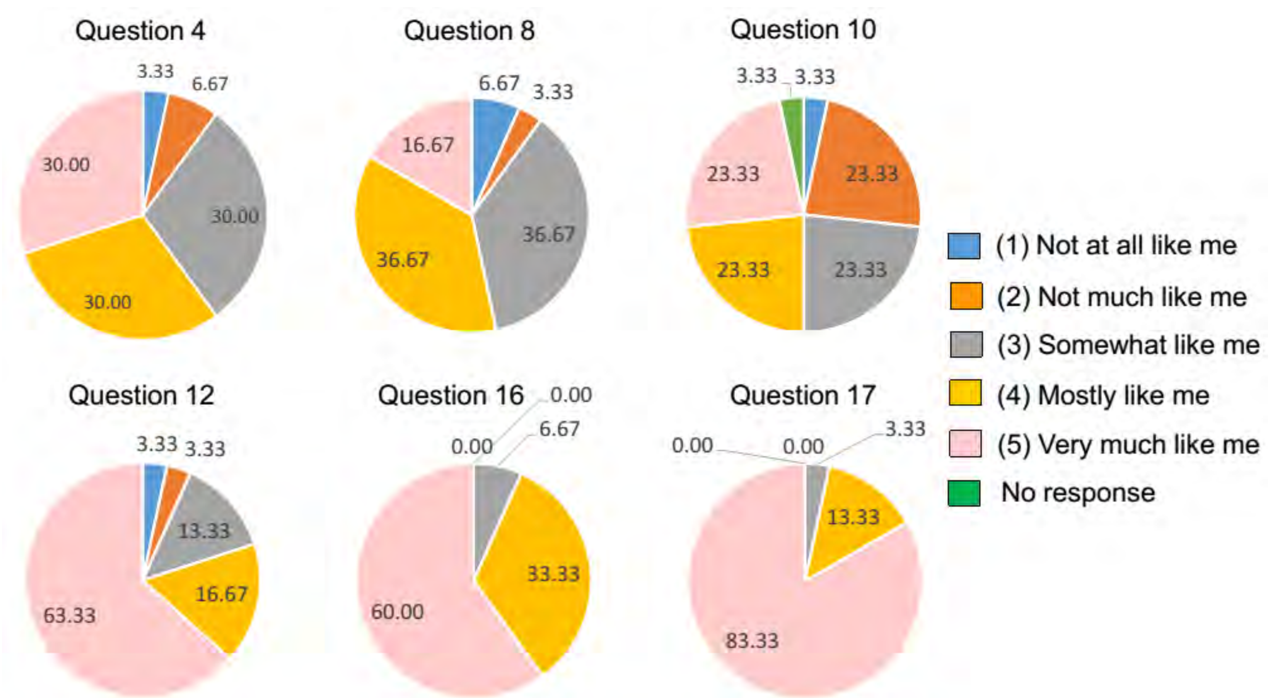

Fig. 5 Results of the questionnaire survey on global competences.
The unit of the numerals in the pie charts is percent (%).

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INVESTMEN PROJECTS FAIR, ENTREPRENEURSHIP CASES

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Abstract

A fair organization of any kind implies coworking and combibing knowledge from different disciplines, such as science, economy, social studies or culture. As a result of this merger, we get a common start for products and services that solve certain problems of today's society.Taking this into account, we decided to apply a strategy in which learning could occur in an active way, based on projects,and marked by the intervention of different areas of knowledge. Some of these fields are financial math, administration, economy, accounting, law, ethics, among others.This fair had its origin in may 2013 with the iniciative of two teachers and their interest to motivate the students to learn in a creative form. Six teams of students, only from the economy and administration area, participanted in the first edition.The fourth edition took place in may 2017 imposing a record. Twenty eight teams participated, arranged in three different categories, set according to the students' training level (2nd, 4th and 6th semester). Since then, this fair has been evolve year by year incorporating new methodologies and trends. The preparation process for this projects fair begins in january of each year and it is carried out in the final days of may. In this period teachers and students work together inside and out of class. At the end, students present their work made during this period and it is assessed by an external jury. Each team has at least an advisor professor, who accompanies the students in the development process of their project, with this, the skills of each team member are enhanced, reaching self-learning. Also, each team gets general training from the organizing committee to ensure uniformity and development of all the teams. One of the biggest benefits of this projects fair is the significant learning, the development of innovations, creativity and the integration of all the university comunity.

Keywords: *integral projects, active learning, collaborative work, transversality, linkage.*

Introduction

The role of the teacher today is much more than transferring knowledge. That commitment that is generated when a teacher is in front of a group of students also includes motivating research and solving everyday situations in their life context, in order for them to do their knowledge can be applied, and with it the quality of education is obtained at all levels, as one of "the objectives of UNESCO established for infants, young people and adults. The above based on the development of competencies that give students confidence and also transform their lives to a degree that generates an impact on the community to which they belong".

The teaching strategies embodied in this "Investment Projects Fair" has a relevant role in the obtaining of a quality education, as it motivates the student not to settle only with the information that the teacher in charge of the subject shares, it also leads the student to take the initiative in research and ask questions about what situation or problem it´s needed to solve and how can they do it. On the other hand, the student will require advice from several teachers from different areas of knowledge, this need, guide the student in active and complete training.

Materials

According with the Mexican provisions of the Integral Reform of the Upper Middle Education, RIEMS (2008), it is important to highlight that, in order to consolidate a quality education, and therefore contribute to the graduation profile of the high school student, (Secretarial Agreement 445), it is necessary that the teachers are duly updated and have the respective competences (Secretarial Agreement 447). and with constructivist theories that seek to enhance knowledge in ways of educating in the current society.

For this reason, the proposal developed at the high school of Salamanca (ENMSS for its initials in Spanish), consists of integrating different knowledge of the students in an integrating project, where the student develops competences, through a guided process and accompanied by one or more teachers, with the intention of implementing it in their environment, socialize it and link it directly with society through a public exhibition, thereby achieving the educational needs of the new generations and of our society.

The proposal to develop integrating projects that function as a instrument to mobilize the different knowledge of the students, is an idea that arises as a response to the need to give practicality and significance to the knowledge acquired, and also is the idea that gives origin to the Investment Projects Fair, which today has been consolidated as an institutional strategy.

Methods and Pedagogy

Backgrounds: Before to the emergence of the Investment Projects Fairs, the first initiative occurred in the semester January - June 2013, after some students, constantly stated that the elements provided in the classrooms had no real application in their lives. This situation motivated to change the way of teaching the subject, and it was implemented experimentally with the 6th semester group A students of the Administrative-Economic profile, taking advantage of the climate generated within the subject of Projects Analysis Investment, which facilitated the realization of projects as part of the teaching-learning process.

The objective was for students to develop business ideas by applying the theoretical knowledge of the subject, complementing and relating it to the content of other subjects in the area, to structure a project applicable to the local environment.

With the results obtained from this first generation of projects in the administrative area, the option of carrying out an "Investment Project Fair" in which students show their projects to the rest of the university community, school authorities and general public. Unfortunately, being the initiative of a single teacher, it was not possible to do it, but the idea remained.

First event 2014. Based on the previous experience and once the results obtained were socialized with the teachers of the area, and validated by the academic authorities of the ENMS Salamanca, we obtained the support to organize the first investment project fair, in which participated the two groups belonging to the profile Administrative Economic.

This event served to make known to the entire university community the work and skills acquired by the participating students, but in the same way it contributed to other teachers being interested in developing this type of activities and decided to contribute from their areas of knowledge, for enrich the student projects.

Second event 2015. In this year, the “Investment Project Fair” turned into a fundamental part of the area Administrative-Economic, as this time the projects were evaluated by the level of theoretical transversality and skills acquired. In this edition, a work team was consolidated among the teachers of the area, and second-semester students from the subject of Projects and Personal Economics were invited to participate, as well as the 6th semester of Social Sciences and Humanities area.

Third event 2016. In this year, the investment projects fair acquired a new perspective due to being identified as an institutional and transversal event, it was improved with the participation of a greater number of students, as well as with the support and advice from teachers in different areas. This third edition had a team of external evaluators who collaborated to give feedback to the participating teams, and a representative team was selected.

Another element to highlight is that due to the satisfactory results of the previous fairs, the proposal could be shared with the College, which is the institution who directs all the 11 high schools that are part of the University of Guanajuato, and at this form the sister schools carried out their first samples of projects.

Likewise, knowing the strengths developed by the students, the representative team were selected to participate in the 11th Creativity and Innovation contest, obtaining second place (Figure 1).

Figure 1. Team winner of second place in the 11th contest of creativity and innovation 2016. Guanajuato University. Mexico.

Expansion and growth. Thanks to the achievements of the previous years and the training of the teachers involved, the fourth edition of the investment projects fair acquired new dimensions since it has been fully institutionalized (Figure 2). This year, a general announcement was launched and participated a total of 28 teams of students from the second, fourth and sixth semesters; it should be noted that the participation of these teams was not limited by the group or area that they studied, since there existed the option to integrate multidisciplinary teams, which allowed the diversification of projects. In the same way, a new group of teachers integrated to advise the teams of students.

We had a special team of graduate students who participated in past years, and returned to help and provide training to students during the year, with the aim of providing additional elements to those acquired in class, motivating participation in the development of projects as learning strategy, but also as an experience for the development of life skills.

One of the innovations applied in this event was the use of the pitch methodology for the presentation of projects, and the Business model CANVAS as a method for develop projects ideas. There was a group of experts who acted as evaluators, the competition modality was assumed, and the best teams were selected to follow up on their projects and register them in the 12th creativity and innovation competition. In the same way, it was possible to share the results of this event with the initiatives of the Upper Middle Schools, since the winning teams participated in the first investment projects fair with 10 schools more.

Figure 2. Students presenting their project "Cone Food". Salamanca High School Gymnasium. Mexico.

Transformation of the methodology. Since its inception, the methodology applied for the development of each investment projects fair is supported by learning based on projects. For the application of this method, it is imperative that three essential events take place: the first is that the teachers who lead and are responsible for organizing the fair, work as a team, including teaching together.

The second essential event is a training for the students, which must be transversal, that is, all the subjects they take provide them with elements that they can relate and apply in a single project, but also students must identify their own skills and take advantage of them efficiently in the development of their projects and based on their skills and knowledge they integrate into multidisciplinary teams. Finally, it is essential to have a team of external collaborators, such as graduate students, or experts in different areas of knowledge, who can help at different moments to complement the training of students and the development of their projects.

The annual event, which is called the investment projects fair, is only the closing activity of an annual process, which begins in the month of August, when the teachers have first contact with the students. From that moment on, the aim is to give them a series of workshops and activities that provide the student with elements related to creativity, leadership, teamwork, communication, and notions of marketing.

In the semester that begins in January, the training of the students is monitored through a diagnostic analysis that helps them to identify the main needs, problems, or opportunities that they can address through a project. They are given a series of additional trainings to their subjects, so that they have enough elements and can integrate work teams.

The first training course they are given is from CANVAS, so that they can decide the focus of their project. During the semester the students acquire several knowledges of their other subjects and apply them in the development of the project, almost at the end they receive training specifically in the PITCH methodology to make their presentation. In the month of May the final event is organized, the projects fair, in which each team prepares a stand and makes a presentation of their project.

The entire school community attends this event and a group of experts participates to evaluate the projects and provide feedback. The three best teams are selected, which participate in a project fair with the best teams from the 11 schools. Finally, the selected teams participate in the annual creativity and innovation contest organized by the University of Guanajuato (Figure 3).

Figure 3. Team winner of second place in the 13th contest of creativity and innovation 2018. Guanajuato University. Mexico.

Results and Discussion

One of the greatest achievements, has been to link the proposals of the 6th semester students with university level and external institutions to give continuity to their projects. It should be noted that the projection achieved with project fairs is only the result of learning processes that are worked on, gradually and from different areas, integrating in a single sample the interpersonal skills, knowledge and abilities developed by the students.

Likewise, with this method, we can observe a synergy of work between students and teachers, which greatly favors creativity, collaboration and integration.

Certainly the main benefits that we have observed from the implementation of the projects fairs as a central method, is the gradual reduction of students who fail the subject, in contrast, individual performance gradually improves. The development and strengthening of self-esteem is observed in the students, who develop notable improvements in their social, communication and collaborative work skills. The student learns to solve conflicts, to value self-taught learning and broadens his vision of the environment in which they live.

Currently, some outstanding students who participated in the first editions of the project fairs, have joined the external support team, eventually return to share their new learning, some of them teach workshops and lectures to current students, and have been follow up on their projects that they started in high school, which greatly enriches the experience of the students.

The impact that the project fairs have had on the students, the school and the teachers who started this project, has led it to be adapted to the new academic structures that took place from 2017, currently they are also carried out every year a gastronomic exhibition (Figure 4) and a philosophy market, following the same work methodology, but applied to the subjects of Personal Training and Introduction to Philosophy, both in the 4th semester.

Figure 4. Team of students presenting the state of Oaxaca into the gastronomic exhibition 2019. Salamanca High School Gardens. Mexico.

Conclusions

The learning based on projects requires perseverance, commitment, review of progress and a better effort from all involved (teachers, students, the school, even the society), in order to see the work completed and ensure that the potential of each member of the team is developed at maximum level. With this, the self-learning is achieved, directed and matured step by step for each student, because they recognize and value their own work, and are involved in each area of knowledge that is needed in the process of the project, in addition to promoting research,which is so absent in many of the students' educational processes. This promotes an active and effective methodology, since knowing the reality and problems of its context also motivates personal growth and an openness of the student considering himself an agent of change.

Acknowledgements

We thanks to the University of Guanajuato for its support in strengthening substantive activities for the preparation and continuous improvement of its teachers, and the development of activities that lead the student to increase their experience in the development of new knowledge.

We also thanks to the ENMS of Salamanca for their support in carrying out the Investment Project Fairs.

To our fellow teachers, who supported this project in an enthusiastic and motivating way.

Of course to all the students that each year participate with their projects, without them this would not be possible.

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PBL FOR DEPLOYMENT OF AGRICULTURAL AND ENGINEERING COLLABORATIVE EDUCATION

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Abstract

The needs to improve agricultural productivity is being recognized worldwide. In Japan, agricultural advancement has been required for industrial competitiveness. To promote the industrialization of agriculture, various activities have been carried out, such as plant factory installation, ICT implementations and introduction of robots. Non-agricultural companies are also entering the agricultural industry. In our college, it was concluded that it is important to train engineers with agricultural skills in a two year survey. In addition, we studied the educational curriculum for training engineers with agricultural skills. The required engineer is an engineer who can design systems to produce creatures on the basis of engineering expertise. This kind of education is named "Agri-Engineering education". The curriculum consists of two different elements, agricultural education as a "Horizontal thread", in addition to the engineering expertise education as a "Vertical thread". The following four elements are necessary for agricultural education, (1) farm tours of examples in need of industrialization to improve motivation, (2) basics of biology and agriculture for industrialization to produce creatures, (3) experiments for understanding of difficulties and pleasure to produce creatures, (4) Project Based Learning (PBL) and system design for cultivating an industrial management. As for the experiment for understanding of producing creatures, PBL has been implemented in advanced course curriculum. The subject named "Project Based Experiment (PBE)" has been implemented for the first grader students of advanced course. The purpose of this subject is to achieve our aims of education which is to learn inquiry, analysis, imagination and ability of design to solve various problems. Our college has four major departments, mechanical engineering, electrical and electronic engineering, information technology, and civil engineering as five-year associate degree course. Each group consists of students from those majors to learn the project in this PBL experiment in the two-year advanced course. Collaborative work would be needed to solve the problem. The assigned theme changes every year, such as "Production of automatic plant cultivation system", "Production of experimental equipment for optimizing plant cultivation conditions" and "Production of optimal environment maintenance equipment for plant cultivation". Through this subject, our students cultivated agricultural skills on the basis of engineering expertise.

Keywords: *Project Based Learning (PBL), agricultural education, creature production, engineering expertise, curriculum.*

Introduction

In 1960s, National Institute of Technology (NIT, KOSEN in Japanese) was established for the purpose of developing human resources in the secondary sector of industry. Our institutes have contributed to Japan's breakthrough as a world leader in technology. Since then, we have been producing engineers in the third, fourth and fifth sector of industries with the demands of the era. However, we have not contributed to producing engineers for the primary sector of industry, such as agriculture, forestry and fisheries. In Japan, declining population and aging of agriculture, forestry and fisheries workers is a social problem. In addition, agricultural advancement has been required for industrial competitiveness. Therefore, supporting agriculture through industrial technology is one of the national challenges. To promote the industrialization of agriculture, various activities have been carried out, such as plant factory installation, ICT implementations and introduction of robots. In our college, a two year survey for engineering education with agricultural skills was conducted from 2014 to 2015, financial supported by headquarters of NIT.

The survey was conducted not only in Japan but also in advanced countries of agriculture such as the Netherlands, the United States, and South Korea. The current situation, problems and future prospects of industrialization of agriculture, desirable engineers, technical materials, etc. were investigated. Yoshizawa et al. (2015) reported the survey results. As a result of survey, it was concluded that technology to produce creatures is a new activity field for industrial engineers, including our college graduates. Therefore, new curriculum to educate engineers with agricultural skills has been implemented since 2016.

Pedagogy for Agri-Engineering

Desirable engineers are those who have a basics of agriculture, have a sense of handling "living creatures", and have a management perspective, on the premise of deep acquisition of industrial technology. Therefore, our goal is to educate engineers who can design systems to produce living creatures on the basis of their engineering expertise. This kind of education is named “Agri-Engineering education”. The curriculum consists of two different elements, agricultural education as a “Horizontal thread”, in addition to the engineering expertise education as a “Vertical thread”, as shown in Figure 1. The following four elements are necessary for agricultural education, (1) farm tours of examples in need of industrialization to improve motivation, (2) basics of biology and agriculture for industrialization to produce creatures, (3) experiments for understanding of difficulties and pleasure to produce creatures, (4) PBL and system design for cultivating an industrial management. As for the farm tours (1), it is important to make students understand that a field of agriculture is also industrial engineer's field and be aware of the agricultural issues. As for the basic education of biology (2) and experiments (3), this is for the purpose to learn the basics of biology and agriculture necessary as an industrial engineer. Takahashi et al. (2017) developed and published a text book entitled “Introduction to Agriculture for Industrial Engineers" and opened a new subject for advanced course students. As for the PBL and

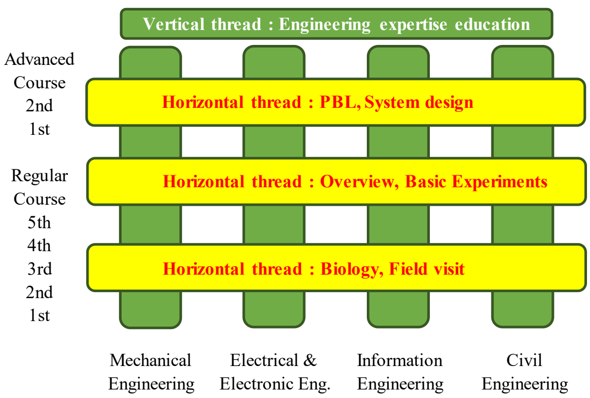


Figure 1. Horizontal thread education

system design for cultivating an industrial management (4), PBL subject has been implemented in first grader of advanced course curriculum. The subject was named “Project Based Experiment (PBE)”. The purpose of this subject is to achieve our aims of education which is to learn inquiry, analysis, imagination and ability of design to solve various problems. In this subject, students try to challenge "manufacturing" for given problems with collaborative work on the basis of their expertise.

PBL for Agri-Engineering

In recent years, Problem Based Learning or Project Based Learning has been in the spotlight for a new method of education. Barrows and Tamblyn (1980) approached PBL for Medical Education. Heywood (2005) developed curriculum and instruction for engineering education. Tan et al. (2005) approached PBL as a new directions for Polytechnic students in Singapore. In our college, some attempts have been made to implement PBL in some subjects. One of the first attempts to implement PBL was “Project Based Experiment (PBE)” for advanced course students. This subject PBE has been conducted since 2003. Since 2015, presented theme of PBE has been changed to “Agri-engineering”.

Challenge theme: In FY2015, the challenged theme was “Production of automatic plant cultivation system”. In FY2016, the theme was “Production of experimental equipment for optimizing plant cultivation conditions”. In FY2017 and 2018, the theme was “Production of optimum environment maintenance equipment for plant cultivation”. In FY2019, the theme was “Proposal and making prototype of the problem solution for agricultural engineering”. In our college, many research works related to agriculture problems have been conducted since Agri-Engineering education started. There are many problems related to agriculture, some of which may be solved by engineering approaches. In this subject, students propose engineering solutions for agricultural problems and try to make prototypes for solving the problems. In this paper, FY2019 result is reported.

Goals: The purpose of this PBE subject is to achieve our aims of education which is to learn inquiry, analysis, imagination and ability of design to solve various problems. The goals of this subject PBE are as follows. The students should :

1) have a discussion with their group, and make themselves understood with their own opinion.

2) take action with their own specialization to manage the problem.

3) be able to create images with original idea, and to design the method of realization of their image.

4) be able to appeal the features and advantages of their works with presentation or report.

Our college has four major departments, mechanical engineering, electrical and electronic engineering, information technology, and civil engineering as five-year regular course (associate degree course). The advanced course is composed of two fields of study, which have their basis in the regular course, (1) Mechanical Environmental System Engineering, with its bases in Mechanical Engineering and Civil Engineering, (2) Electrical, Electronic, Information Engineering, based on Electrical & Electronic Engineering and Information Engineering. In this subject, all of the advanced course students have to take the class at the same time. In FY2019, 21 students are enrolled in the advanced course. The students are divided into two groups in this subject. Each group consist of 10 or 11 members who have their basis of four majors, mechanical, electric and electronic, information, and civil engineering. Project was carried out with collaborative work.

Regulations: Students have to propose and produce a prototype of the problem solution for agricultural engineering, which performs more impressive functions under limited conditions. There is no restriction to the size of prototype, but it should be mobile. The total cost of the production is limited to 80,000 JPY for each group. All of the items and materials are purchased after they are determined by group members from the order catalogue or DIY shops. Each group carries out planning, designing, and manufacturing to realization their original devices. If the students work outside of class hours, students have to calculate the labor cost, and calculate the total production cost to the manufactured prototype.

Schedule: The class was held twice in a week, and the total lessons were 26 in one semester. Each class was planned step by step to achieve the project as follows.

1st lesson: Explain the project outline

2nd lesson: Short training for mechanical processing, electric circuits and programming

3rd lesson: Field visit to Agricultural Research Institute

4th to 7th lessons: Idea generation & discussion

8th lesson: Midterm presentation (Idea competition)

9th to 23rd lessons: Design & Manufacturing

24th lesson: Final exhibition

25th lesson: Final presentation

26th lesson: Feedback and reflection

One of the important things in the project is management of the task. The group leader of the student had to manage and supervise the task and schedule of the project. For this aim, "Task management sheet" shown in Figure 2 was used.

Assessment: The assessment of this subject is combination of the marks as follows.

1) 25% Final product
2) 20% Final Report
3) 25% Final presentation
4) 15% Operational records
5) 10% Self-assessment
6) 5% Peer-assessment

The assessment is based on the "difficulty" and "achievement" of the task set by the students. It will be highly evaluated if the students can achieve a task with a high degree of difficulty with a high degree of completion. If the task difficulty is low, high degree of completion will be required. As for the operational records, each student must complete operational records, and checked by faculties every time. The assessment was reflected by each student's effort based on operational records sheet. The operational records was included the marks of the self-assessment and peer-assessment between the students. These assessments were reflected by each student's effort, aggressiveness and ability to solve the problems.

Results and Discussion

Learning outcomes: The Final products which manufactured student teams were shown in Figure 3 and Figure 4. Figure 3 shows the final products of team A, this team concept is "Automatic plant cultivation system". The system was equipped with automatic sowing which was automatically controlled by the sowing device, automatic sprinkler controlled via the internet, and automatic temperature and humidity check function for uploading web servers. In the final exhibition, this system

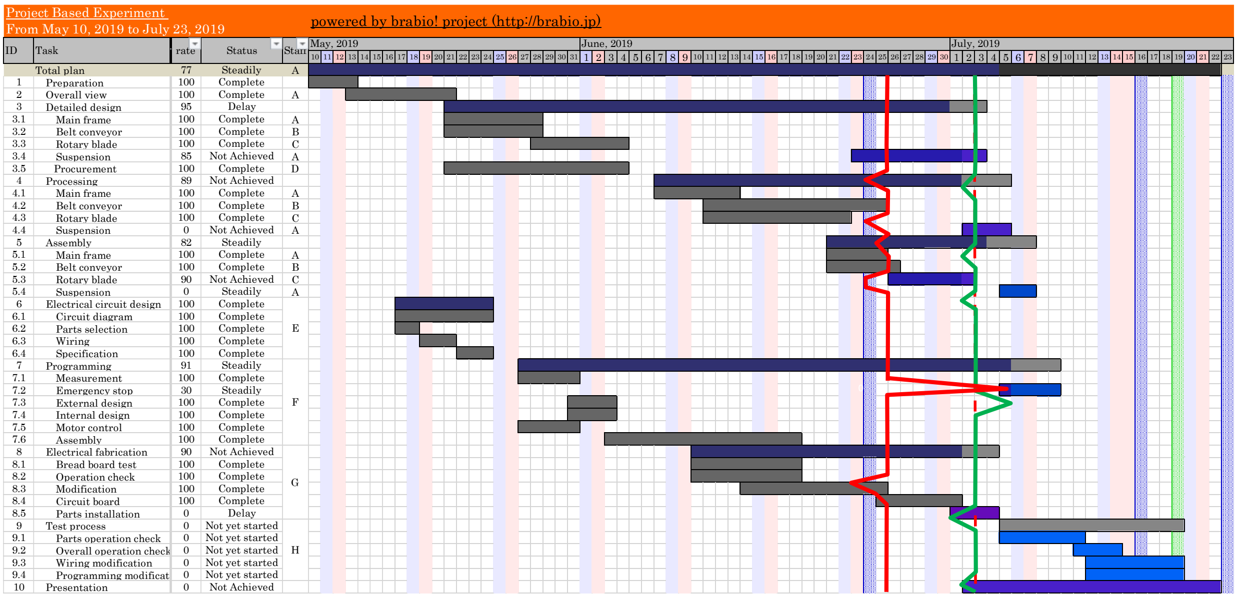
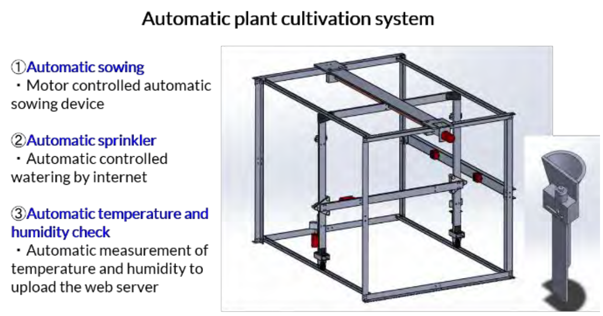
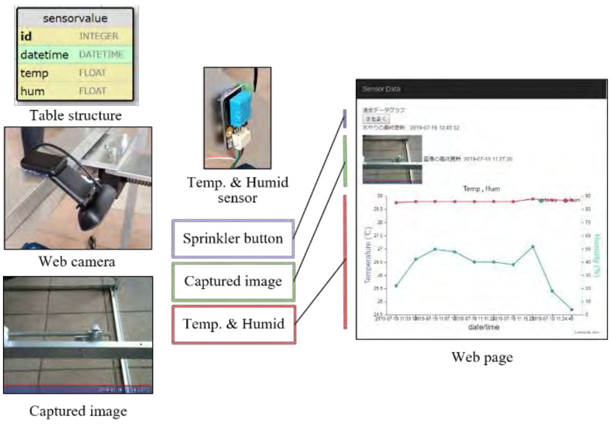


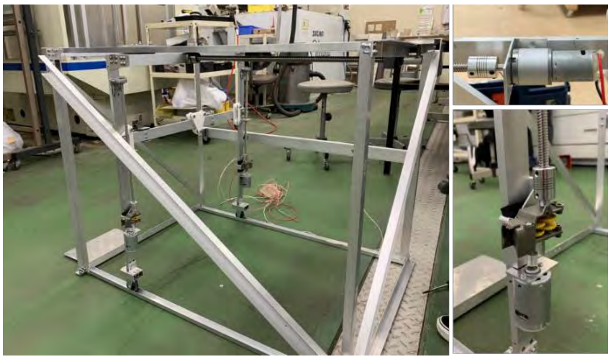
Figure 2. Sample of task management sheet



(a) Prototype design of team A

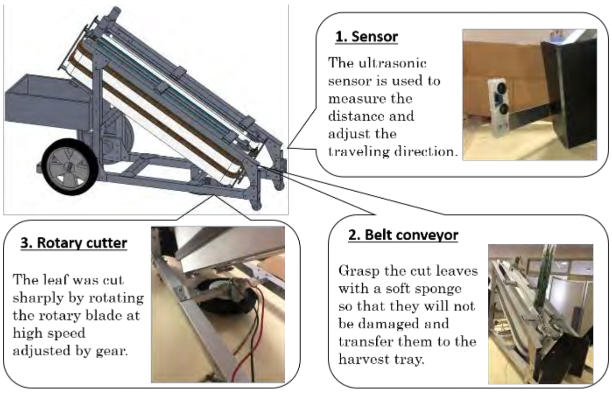


(b) Detector design for prototype of team A

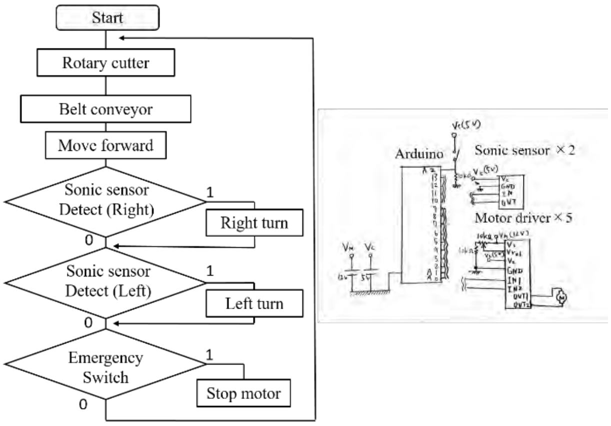


(c) Manufactured prototype of team A

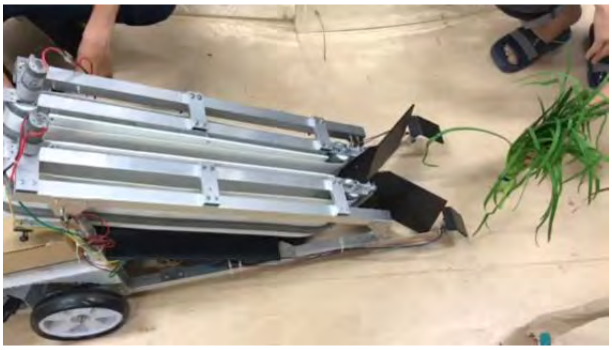
Figure 3. Final products of team A



(a) Prototype design of team B



(b) Control design for prototype of team B

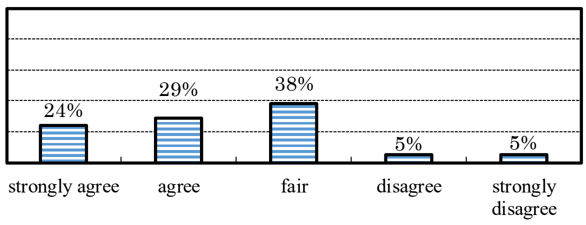


(c) Manufactured prototype of team B

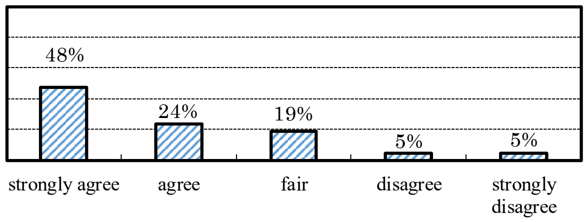
Figure 4. Final products of team B

was not working perfectly, among the planned three-axis drive, only one-axis could be operated. However, as for the automatic temperature and humidity check device, the data was accumulated on the web server, and the data was able to checked through the web browser. In addition, the webcam was working properly, so that it was possible to check the plant growth with practical usage. As for the task manegement, the schedule was delayed by the parts ordering failure. This is because the information exchange for design and specification changes did not work well among the team members. As a result, our students were able to learn the importance of information exchange and the importance of schedule management.

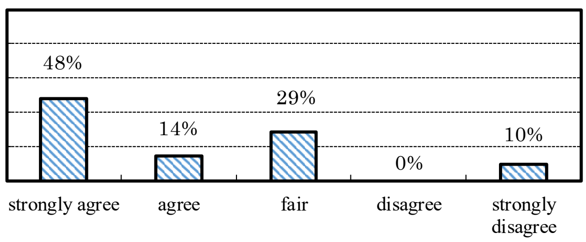
Figure 4 shows the final products of team B, this team concept is "Chive leaves harvesting robot“. The robot was equipped with ultrasonic sensor which measured distance to the leaves and controlled traveling direction, rotary cutter for cutting sharply the leaves by adjusting geared speed, and belt conveyor which grasped the cut leaves with a soft sponge not to be damaged to transfer them to the harvest tray. As a result of the robot operation test, the robot could detect the leaves automatically with the sensor and harvest automatically. As for the task management, the mechanism group schedule was delayed by about 3 weeks from the initial schedule. The main reason for the delay is considered to be the load was



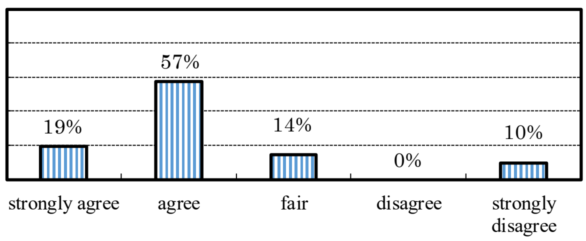
(a) Q: Have you felt PBL is effective method of learning?



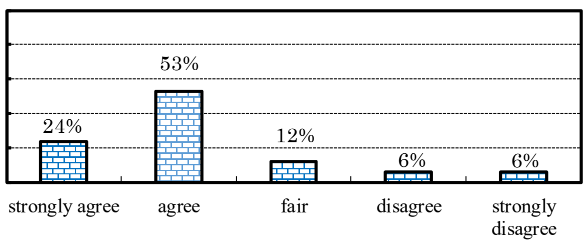
(b) Q: Have you learnt the process of manufacture?



(c) Q: Have you experienced pleasure of creation?



(d) Q: Have you built up cooperativeness?



(e) Q: Has your interest and understanding about agricultural problems increased?

Figure 5. Questionnaire for satisfaction

concentrated on some people who could conduct detailed design. However, in processing and assembling, some of the delayed schedule was recovered with sharing all team members. As a result, the final manufactured product was completed with practical usage under the regulations. Our students were able to learn the importance of cooperativeness and schedule management. In addition, this team achieved high accomplishments, and they experienced high pleasure of creation as for manufacture.

Effect of education: Figure 5 shows the results of the questionnaire of satisfaction after the end of the class. It shows the results of five questions as follows.

(a) Have you felt PBL is effective method of learning?

(b) Have you learnt the process of manufacture?

(c) Have you experienced pleasure of creation?

(d) Have you built up cooperativeness?

(e) Has your interest and understanding about agricultural problems increased?

Each result shows high satisfaction of students. Overall, this subject PBE achieved strong effects of education, compared with the other conventional classes. As for the question (a), the most answered is “fair”. This is because our college have implemented PBL for long period since 2003 as for the PBE, our students might have felt as a normal pedagogy. Otherwise, as for the questions (b) and (c), high satisfaction was achieved. This is because this subject PBE is the only subject to experience and learn the process of manufacturing. It was the first time for a student to experience manufacturing to find and solve real-world problems by themselves. As for the question (d), many students recognized the importance of the cooperativeness. For both teams, the main reason for the delay in schedule was the lack of mutual information exchange and the lack of cooperation among team members. As for the question (e), relatively high degree of satisfaction was obtained. Many of the students faced and researched the real problems of agriculture, at the early stage of idea thinking. It seems to be cultivated interest and understanding about agricultural problems. However, it was disappointing that some students could not find a relationship between agricultural problems and their expertise. For the future work, we have to improve the students to make them more interested and understood about agricultural problems.

Conclusions

In our college, a two year survey for engineering education with agricultural skills was conducted. It was concluded that technology to produce creatures is a new activity field for industrial engineers, including our college graduates. Therefore, new curriculum to educate enineers with agricultural skills has been implemented since 2016. This kind of education is named “Agri-Engineering education”. The curriculum consists of two different elements, agricultural education as a “Horizontal thread”, in addition to the engineering expertise education as a “Vertical thread”. As for the Project Based Learning (PBL) for cultivating an industrial management, "Project Based Experiment (PBE)" has been implemented in first grader of advanced course curriculum. Since 2015, presented theme of PBE has been changed for "Agri-Engineering". In FY2019, the theme was "Proposal and making prototype of the problem solution for agricultural engineering". The final product of team A is "Automatic plant cultivation system", while that of team B is "Chive leaves harvesting robot". These final manufactured products were completed with practical usage under the regulations. However, as for the task management, both teams had to need more improvements. Overall, this subject PBE was achieved highly effect of education. As the results of this subject, some effects of education were obtained.

(1) Students learned themselves the process of manufacture with realization of their images.

(2) Students experienced and learned the process of manufacturing.

(3) Students recognized an importance of cooperativeness and communications.

(4) Students cultivated interest and understanding about agicultural problems.

Based on these results, we would like to revise this subject to obtain more strong effects of education.

Acknowledgements

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The development and effectiveness evaluation of Nara Kosen's engineering education system for women

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Abstract

With the progress of industrial globalization and the fusion of technologies from different fields, value-creating-type human resources development is being sought to create items and methods with new values on the basis of diversity and inclusion. In Japan, as the birth rate falls and society ages, women are expected to participate at higher corporate levels.

The National Institute of Technology, Nara College (Nara Kosen), launched the "SHINAYAKA Engineer Education Program" in FY2019 to train female engineers. The program's curriculum focuses on sensitivity and expressiveness to develop engineers who have both strength and flexibility. The results of a questionnaire survey indicate that female students are keenly interested in "sensitivity" and "expressiveness," which therefore have high affinity to female student education. The curriculum consists of three main subjects: (1) subjects to enhance sensitivity through traditional culture or life environment design and develop the ability to see things from different points of view, (2) subjects to develop the ability to connect multiple viewpoints obtained from knowledge or sensitivity for improved creativity, and (3) subjects to develop expressiveness to bring functional, social, and emotional values to people as actual things. Through the education program, Nara Kosen aims to develop sensitivity and expressiveness of students and train engineering leaders who can see manufacturing from an objective viewpoint and create new values by taking advantage of the synergistic effects of learning from different fields in addition to Nara Kosen's proven engineering education.

In this paper, we introduce the SHINAYAKA Engineer Education Program and example lectures, and examine from multiple viewpoints the educational effects of the program and its future challenges based on analysis of the review sheets completed by students after lectures.

Keywords: *Women's Empowerment, Diversity Inclusion, Development of Woman Engineer, Sensitivity, Expressiveness*

1. Introduction

In recent years, the transfer of production bases overseas has accelerated the globalization of industry and its influence has affected not only product manufacturing but also product development, logistics, and consumption. Furthermore, technologies in different fields are rapidly progressing fused and more complex. For example, there have been innovations in production processes using IT, IoT, and AT, which support industry, the creation of high values to add to products, and the development of new business models. To create new innovations in these circumstances, collaborative efforts to realize diversity and inclusion are needed for the same goal across different socio-cultural backgrounds, including different personal characteristics, and different senses of values, and value-creating-type human resources who can produce items and methods having new values are very important.

In FY2019, Nara Kosen started the "SHINAYAKA Engineer Education Program" to develop engineers who can respond to this diversification. 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. One objective of the program is to fuse the practical skills developed through engineering education and the abilities developed from different fields to develop strong, innovative engineering leaders who can create new values to people's lives with a new concept, story, or value added to the product. We refer to such leaders as "SHINAYAKA engineers" with high adaptability and strength.

The "SHINAYAKA Engineer Education Basic Program" (hereinafter referred to as the "SHINAYAKA Program") was started in FY2019 as a subprogram of the SHINAYAKA Engineer Education Program, with the aim of enhancing the sensitivity and expressiveness of the students in regular engineering courses. In this paper we present the curriculum details and examples of lectures and workshops conducted in FY2019 of the SHINAYAKA Program. Moreover, we examine the effects of the education program using students' reviews completed after each lecture and a questionnaire survey.

2. Background and significance of female engineer development

In Japan, the ratio of female engineers is still low, so the SHINAYAKA Program emphasizes the development of female engineers. In the IT industry, for example, the ratio is 14.3% in 2019[1]. It is expected that the industry will have a shortage of about 449,000 IT workers by 2030 accoring to Ministry of Economy, Trade and Industry[2]. In April 2016, the Act on the Promotion of Female Participation and Career Advancement in the Workplace was enforced. Since then, work environments for women have been improved and work opportunities for female engineers have become wider. Expectations for female engineers are thus getting higher. For example, for Panasonic's beauty appliance "Panasonic Beauty," product planning and technological development are made to respond to woman-specific needs and favors taking advantage of female sensitivities and many innovations have been made from a woman's point of view[3].

With this situation in mind, Nara Kosen concentrates on the development of female engineers who can express their creativity from different perspectives from conventional engineering and create problem-solving innovations. The SHINAYAKA Program thus emphasizes the enhancement of "sensitivity" and "expressiveness" by learning from non-engineering fields. By developing knowledge and methods of thinking through the learning from non-engineering fields, the program enables students to understand manufacturing from an objective viewpoint and create new values.

3. Outline of SHINAYAKA Program

3.1 Curriculum configuration of SHINAYAKA Program

The SHINAYAKA Program consists of three main courses of lectures as shown in Fig. 1:

(1) Lectures to develop "sensitivity" for seeing things from multiple viewpoints

This aims to increase the variety of students' knowledge through lectures and workshops for knowledge other than engineering and encourage students to understand the production of things from different viewpoints. Primarily, students learn "sensitivity" from the three viewpoints shown in Table 1 (Sensitivity learned from traditional culture, sensitivity learned from life and society, and sensitivity learned from psychology).

(2) Lectures to develop the ability to connect multiple viewpoints

The ability to connect multiple viewpoints acquired from knowledge of engineering and classes of "sensitivity" and create new values is developed.

(3) Lectures to develop "expressiveness" to realize values

With the lectures, students acquire expressiveness to transfer values in a visible form to other people. Primarily, students learn "expressiveness" from the three viewpoints shown in Table 2 (Expression to transmit functional values, expression to transmit psychological values, and expression to transmit social values.)

With the curriculum based on these three courses, the students can make "notes" and "connections" of the notes and acquire the ability of "creation" of new things.

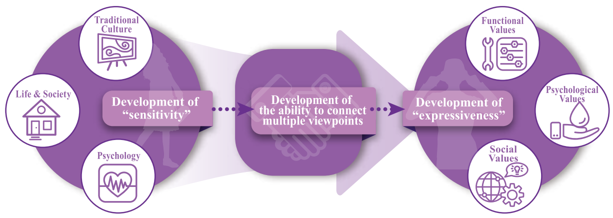


Fig. 1 Curriculum structure

Table 1 Viewpoints to develop "sensitivity"

Sensitivity learned from traditional culture	To study less familiar Japanese traditional culture, as well as its history and works, and learn sensitivity.
Sensitivity learned from life and society	To study designs in various fields that students see in their daily lives, learn what these designs are like and how they are created, and touch the designs in order to enhance sensitivity.

Sensitivity learned from psychology	To think about sensitivity itself on the basis of people's ways of feeling about things.

Table 2 Viewpoints to develop "expressiveness"

Expression to transmit functional values	To learn ways of expressing functional values such as the convenience and safety of products and services.
Expression to transmit psychological values	To learn ways of expressing comfort and beauty of products and services, appealing to the five senses.
Expression to transmit social values	To think of ways in which products and services contribute to society and learn ways of expressing them.

3.2 Courses of SHINAYAKA Program

The SHINAYAKA Program is composed of the eight courses shown in Fig. 2, which include subjects not included in the regular program.

(1) Engineer's sensitivity and expressiveness I-IV (1st to 4th grades)

In accordance with the curriculum structure in Fig. 1, experts and specialists in various fields were invited as lecturers and omnibus-format lectures were provided to enhance the sensitivity and expressiveness of the students.

(2) Basic/applied/general innovative workshops (1st to 3rd grades)

Problem-solving learning was provided through practical exercises to obtain knowledge of traditional culture and digital technology and practical training in a local society. For the workshops, the students were grouped to grade-mixed teams. In the workshops, focus was also placed on the development of communication ability and a sense of balancing between identity and cooperation.

(3) Diversity and inclusion (5th grade)

The students acknowledged different experiences, skills, and ways of thinking in various human resource environments and learned how to take advantage of them.

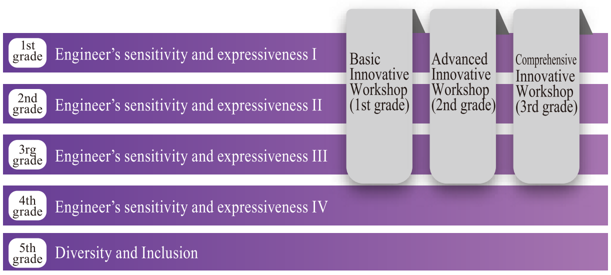


Fig. 2 Course configuration

3.3 Class style of SHINAYAKA Program

Each class of the SHINAYAKA Program lasts 120 minutes with the first 90 minutes for a lecture and the remaining 30 minutes for a review. In the review, the students individually wrote notes about the lecture on a sheet and then the notes were shared in each team. The review by individuals and teams evoked mutual stimulation of the students and widened and deepened their learning. In addition, writing in the review sheet after each lecture resulted in visualization of students' learning and growth. The resulting record could be used to organically connect the subjects with each other and help the students design their own learning.

4. Example of SHINAYAKA Program activities in FY2019

In the SHINAYAKA Program in FY2019, 22 first-grade students (including four male students) enrolled in different engineering courses took the classes after passing a selection examination. As shown in Table 3, in "Sensitivity and expression of engineer I" of FY2019, university lecturers and corporate experts gave lectures on seven different fields to enhance sensitivity and expressiveness, and female engineers succeeding in companies gave two role model talks. In the "Basic innovative workshop," the students were grouped into two teams. A three-day traditional culture workshop was held for indigo dyeing for one team and a three-day digital workshop was held for product design for the other.

The following is a part of the lectures given in FY2019.

Table 3 Class themes in FY2019

Field		Theme
Sensitivity	Sensitivity learned from traditional culture	Sensitivity enhancement by performing art
	Sensitivity learned from life and society	New viewpoint in life: -Design of cheering-
		Design of "learning" and "working"
	Sensitivity learned from psychology	Mechanism of mind in motivation
Ability to connect multiple viewpoints		Let's have a design-oriented way of thinking.
Expressiveness	Expression to transmit functional value	Usability of stationery
	Expression to transmit	Manufacturing and design: -

	psychological value	Survival of small company-
Talks by role models (twice)		Message from female engineer succeeding in company

4.1 "Basic innovative workshop" -Workshop of indigo dyeing-

As problem-solving learning, the indigo-dyeing workshop for the year was designed with three aims.

The first was to establish a diversified environment where students who learn various fields other than engineering can gather and develop the ability of achieving agreement by comprehending difference in the way of thinking and perception. This time, students from a university near Nara known for non-engineering research were invited to join the workshop to diversify the workshop environment.

The second was for the students to directly touch the traditional culture by experiencing an indigo dyeing process of designing and preparing indigo dye, drawing with wax, dyeing, and dewaxing, and to develop their sensitivity to perceive the aim of the production process.

The third was to find a team concept of works based on the assigned theme and develop the ability of team building through making works in a limited time.

On the basis of these aims, the theme of the workshop was "Nara souvenir for foreign visitors to Kosens and universities." Under the theme, the students tried to make a tapestry (40 cm wide and 180 cm long), using a wax method, which is an indigo dyeing technique. They acquired new viewpoints through their experience in a different field, namely, traditional culture. Furthermore, they learned how difficult it is to put various opinions together in each team to create a single piece of work, and experienced fulfilment when they finished the work. This would lead to their future attitude toward making things as engineers.

4.2 "Sensitivity and expression of engineer I" – Sensitivity learned from psychology-

On the other hand, for sensitivity learned from psychology, a lecture titled "The mechanism of mind in motivation" was given by a university psychology lecturer. In the lecture, two types of motivational factors, extrinsic motivation and intrinsic motivation, were explained with experimental examples in psychology. In particular, intrinsic motivation is enhanced by fun and interest level, maintaining willingness and providing many positive effects. The lecture was beneficial because the students were able to grasp the mechanism of low motivation or short-lived motivation in daily life, and learn how to change their focus or how they should cope with it.

This curriculum provided the students with an opportunity to use psychology (which is difficult to quantify) whilst thinking from an engineer's viewpoint.

5. Results and Discussion

Here we examine the effects and problems of the above activities.

We analyzed the SHINAYAKA Program activities in the following two ways.

5.1 Lecture evaluation questionnaire survey

We examined the lecture evaluation questionnaire survey that the students completed after all the lectures finished (the number of responses was 20). In the survey, we checked students' satisfaction level with the lectures.

Question 1 is to check students' satisfaction with the whole program. As a result shown in Table 4, 85% of the students who joined the program answered that the program exceeded their expectations or was what they expected. There were many affirmative opinions. Specific points that exceeded expectations or were just what they expected included "I think I became more SHINAYAKA." "I first thought it was just an opportunity to listen to experts, but actually the program gave us the chance to plan and have unique experiences." and "good place for students to listen to many experts." Therefore, the survey showed that the omnibus-format lectures by external experts were effective for students' learning.

On the other hand, there were also challenges in the program; three out of the twenty students answered that the program was not what they expected because there was a gap between the lecture content and the direction of the students' expectation. In future, we will check the interests and concerns of students in the selection examination and reflect them in the selection of lecture themes under the purpose and aim of the SHINAYAKA Education Program. In addition, to make it easier for the students to feel their learning achievements, specific themes connected to engineering will be selected for the review sheet so that more notes can be extracted as engineers.

Table 4 Students' satisfaction with the whole program.

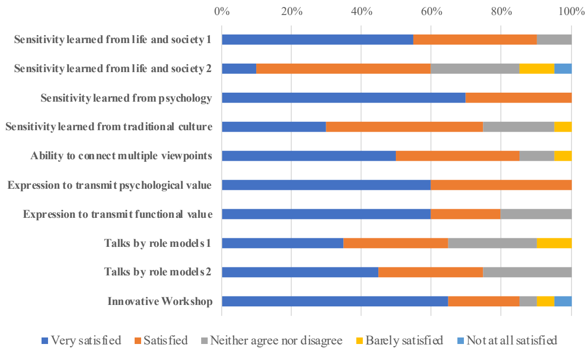
Q1: Were the lectures and workshops of the SHINAYAKA Engineer Education Program as you expected?

Level	Number	Ratio
They exceeded my expectations.	9	45%
They were what I expected.	8	40%
They did not reach my expectations.	3	15%
They were disappointing.	0	0%

We also checked their satisfaction with each lecture in Question 2. The result is shown in Table 5. Although changing depending on the lecture contents, the satisfaction level of most students was high for all the lectures, which probably indicates that the students accepted learning of different fields.

Table 5 Students' satisfaction with each lecture

Q2: How are you satisfied with each lecture?



5.2 Review Sheet

Another method of analyzing the achievements of the program was to use the review sheet. It is difficult to quantitatively measure abilities such as sensitivity and expressiveness that the students develop in the SHINAYAKA Education Program. Therefore, for the evaluation of qualitative features such as sensitivity and expressiveness, we used a text-mining method to extract notes and learning that the students acquired unintentionally from the contents of the review sheets that the students wrote after every lecture by using natural language, and evaluated the quality of their behaviors in the learning process.

In the review sheet, the students described by hand what they noticed in the lecture or learned from the lecture of the day and how they want to utilize what they have learnt. The contents of the review sheet were digitized and divided into words and clauses by a text mining method. Then the students' notes were extracted from the sheet through a correlation analysis of frequency and co-occurrence of words.

Below is the result of the analysis of the students' description about their notes from the lectures. There were 376 description files of notes of individuals and notes shared with 5-6 team members in total and they contained 9518 words (only nouns, verbs, and adjectives). The same words that appeared repeatedly in the same file were counted as a single word. Table 6 shows the top 20 words that frequently appeared in the review sheets of the notes. Figure 3 shows the correlation of the co-occurrence of words. The table and figure indicate that the frequencies of "I," which expresses identity, "think," which is a subjective verb, "people," which is an object, and "can," which is used as a result, are high and the correlation of the co-occurrence of these words is strong. This could be because the students focused on giving an output for "people," with whom values are provided, based on "thinking by myself." It is a different point of view from the conventional engineering viewpoint, namely a theory-based approach to output.

Table 6 Words used to write notes in the review sheet

	Word	Frequency		Word	Frequency
1	I	184	11	Good	72
2	Think	162	12	Do	70
3	Can	159	13	Different	62
4	People	135	14	Understand	52
5	Important	134	15	Product	52
6	Thing	115	16	Feel	50
7	Design	92	17	Learn	50
8	Know	92	18	Now	50
9	Use	92	19	Crucial	50
10	Make	88	20	Change	49

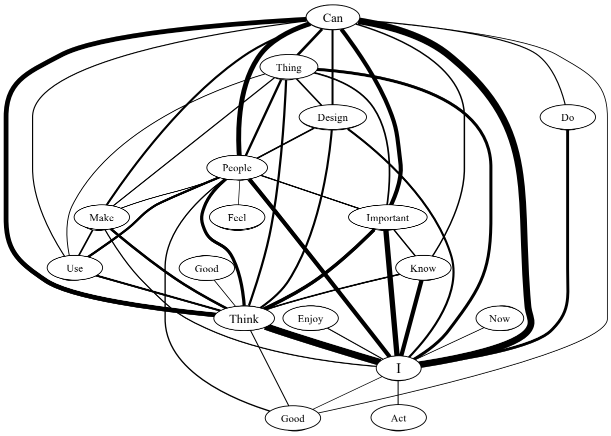


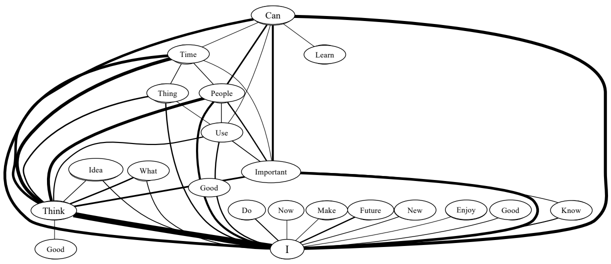
Fig. 3 Correlation of the co-occurrence of words used to write notes in the review sheet

Next, we show the analysis result of the students' description about how they will utilize what they learned from the lectures. There were a total of 201 description files with 4,584 words (only nouns, verbs, and adjectives). The same words that appeared repeatedly in the same file were counted as a single word. Table 7 shows the top 20 words that frequently appeared in the descriptions. Figure 4 shows the correlation of the co-occurrence of words. The table indicates that the frequencies of "I," which expresses identity, "think," which is a subjective verb, and a clear word "idea" are high. The correlation of the co-occurrence in the figure shows that "idea" is correlated with the words "think" and "output." In other words, the students seem to have learned from the lectures the importance and method of creating an "idea" which might be the first step to value creation.

Table 7 Words used to write the useful from lecture in the review sheet

	Word	Frequency		Word	Frequency
1	I	110	11	Learn	36
2	Think	93	12	Make	35
3	Can	70	13	Idea	31
4	Important	62	14	Feel	30
5	People	59	15	Good	30
6	Time	57	16	Future	30
7	Use	49	17	Now	30
8	Thing	44	18	This time	29
9	Know	38	19	Submit	28
10	What	37	20	Design	28

Fig. 4 Correlation of the co-occurrence of words used to write the useful from lecture in the review sheet



6. Conclusions

This paper introduced the educational content of the SHINAYAKA Engineer Education Program, a new activity of Nara Kosen, and reported the effect evaluation of the program based on an analysis of actual students' lecture reviews and a questionnaire survey result.

The survey result showed that the students' satisfaction with learning of different fields in the SHINAYAKA Education Program was high. The student's review after each lecture was analyzed by extracting words from their descriptions and studying the frequency and co-occurrence of the words. As a result of the analysis, we concluded that the lectures of the program provided the students with new viewpoints and notes. In addition, the review after the lectures was effective for the students to acknowledge their growth and the analysis of the review was effective for measuring the growth in terms of "sensitivity" and "expressiveness" whose quantitative measurement is usually difficult. The application of this method would be significantly effective also for measuring learning effects in the program. However, a single-year evaluation alone is not sufficient to verify that "sensitivity" and "expressiveness" acquired from the learning of different fields would be effective for the development of female engineers and therefore continued implementation and evaluation of the program are necessary. In future, we will utilize the program to establish an educational environment where students can create more values.

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IMPROVING STUDENTS PROGRAMMING SKILLS USING SERIOUS GAME

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Abstract

Computer programming is one of the essential skills that IT students are expected to master. However, various publications show that the failure rate and drop-out rate of programming subjects are relatively high. Two main challenges that the students encounter in computer programming subjects are (1) difficulty in bridging the problem solution construction and programing language construction, and (2) insufficient individual-feedback. In this paper, we explore the use of a serious game as an alternative approach to tackle these challenges. Using a serious game, students can fully immerse in a gaming environment and voluntarily spend hours learning new programming techniques. We incorporated a serious game in one computer programming subject for one class of IT students in Temasek Polytechnic. We evaluated its effectiveness in three main criteria, namely: learning outcome, feedback and game experience. Learning outcome criterion aims to measure the impacts of a serious game to initiate and develop programming skills through multi-level game challenges. This criterion was evaluated using pre- and post-game-session tests. The responses show than 16.45% increment in programming skills gained by the students. This increment indicates that 3 out of 19 students were able to improve their programming skills. Feedback criterion focuses on establishing individual feedback within the game environment, and game experience criterion focuses on creating an enjoyable learning environment. These two criteria were evaluated using a survey rated on a 5-point Likert scale, with 5 as strongly agrees, and 1 as strongly disagrees. The survey results show that the average score for feedback and game experience criterion are 4.4 and 3.9, respectively. In addition to the survey, we asked the students to write their experience. We then applied sentiment analysis method to evaluate their feedback. The sentiment analysis results show that the average sentiment score is above 0.68, which suggests a positive game experience. All of these results provide a strong indication that serious game can help students to improve their programming skills and be used as an alternative approach to learning computer programming.

Keywords: *Computer programming, Serious game, Solution construction, Evaluation, Learning outcome, Feedback, Game experience*

Introduction

Computer programming are required subjects for IT students enrolled at Temasek Polytechnic. These subjects are generally believed as one of the most challenging subjects for students with high drop-out and failure rate (Bennedsen & Caspersen, 2007; Bennedsen & Caspersen, 2019; Watson & Li, 2014). It is not surprising as learning to program can be an incredibly difficult task (Bennedsen & Caspersen, 2007; Bornat & Dehnadi, 2008; Feldgen & Clúa, 2006). It requires the student's ability to translate problems or challenges into solutions (Sarpong, Arthur, & Amoako, 2013). It involves knowledge not only in programming tools and languages, but also knowledge in problem-solving and effective strategies for program design and implementation (Sarpong, Arthur, & Amoako, 2013).

Previous publications show that the failure rate of programming subjects are high (e.g. (Bornat & Dehnadi, 2008; Jenkins, 2002; Mendes, Paquete, Cardoso, & Gomes, 2012)). Studies estimate that the passing rate for an introduction to programming subject is around 67% (Bennedsen & Caspersen, 2007; Watson & Li, 2014) while the latest study shows better passing rates with an average of 72% (Bennedsen & Caspersen, 2019).

Difficulties that the students encounter in computer programming subjects can be grouped into ten categories (Butler & Morgan, 2007; Ismail, Ngah, & Umar, 2010; Sarpong, Arthur, & Amoako, 2013). These categories are as follows:

1. Weaker students admitted pursuing CS/IT,
2. Lack of problem-solving skills,
3. Lack of analytical thinking skills,
4. Lack of logical and reasoning skills,
5. Lack of programming planning,
6. Lack of conceptual programming understanding,
7. Lack of algorithmic skills,
8. The conceptual difficulty of various elements of the curriculum,

9. The level of feedback that is available to students about various components of the programming task, and
10. How patterns of study, namely low levels of face-to-face contact experienced by independent learners, impact on the first two issues.

From these ten categories, we can derive two main challenges, namely: (1) difficulty in bridging the problem solution construction and programing language construction, especially for larger programs, and (2) insufficient individual-feedback. The first challenge comes from category 1 to 8, while the second challenge comes from the category 9 and 10.

Recognising these challenges, we explore the use of a serious game as an alternative approach to learning computer programming. The serious game has been introduced as an alternative educational tool for teaching specific knowledge and skills (Ma, Oikonomou, & Jain, 2011), including computer programming (Coelho, Kato, Xavier, & Gonçalves, 2011; Muratet, Torguet, Jessel, & Viallet, 2009). The serious game incorporates non-entertainment elements, such as the programming concept, into the game environment (Liu, Alexandrova, & Nakajima, 2011). It includes complex programming concepts while maintaining the entertainment factors to engage the students for voluntary learning the programming concepts. Furthermore, the serious game would require the students to improve their problem solving, analytical, logic and reasoning, planning and strategising skills to perform well in the game (Wood, Mentzelopoulos, & Protopsaltis, 2015). These skills are aligned with the skills needed to learn computer programming subjects.

In this paper, we used an off-the-shelf serious game for learning Python programming language, named CodeCombat (Code Combat, 2013). We incorporated it into one computer programming subject for one class of IT students in Temasek Polytechnic. At the beginning of the subject, the students were introduced to the game and were given one week time to play the game. To evaluate the effectiveness of the game, we focus on three main criteria as follows.

1. **Learning outcome**: to measure impacts of a serious game to help students to construct programming solutions through multi-level game challenges (i.e. the start levels would be easier than the subsequent levels),
2. **Game feedback**: to measure sufficient individual-feedback to the students during the game session and the impacts of that feedback,
3. **Game experience**: to create an enjoyable learning environment for the students.

For the first criterion, we used pre- and post-game session tests. For the second criterion, we gathered the students' feedback using a survey. While for the third criterion, we used a survey and written feedback. Based on the data from pre- and post-game session tests, surveys, and written feedback, the results provide significantly positive impacts that indicate that the serious game can help students to improve programming skills. It can be used as an alternative approach to learning computer programming.

Code Combat Game

Code combat is a serious game, launched in 2013, to teach people programming and writing programming codes (Code Combat, 2013). It allows the players to use script languages such as JavaScript and Python as the game input to complete the level. The players would need to complete a small story (or challenge) in each level or compete against other players. Code combat has multi-level stories and scenarios with increasing challenges for each level increment (i.e. the start levels would be easier than the subsequent levels).

Code combat is designed as a medieval adventure. It also has several medieval scenarios to introduce various programming concepts. Each player controls one hero (male or female) and goes on a journey to collect gems and defeat multiple enemies by inputting code lines (Yücel & Rızvanoğlu, 2019). For each level, the players are given a set of goals and missions. The players are also provided with a set of restricted code lines that they can use. The players need to write appropriate code lines to complete the mission (i.e. collect the gems and defeat the enemies). The complexity and difficulty level would be gradually increased.

The game environment in Code combat allows the players to input the code lines directly in the game. The players would not need to use a specific programming interpreter tool. However, it would create a similar experience from which the players can go on to learn programming more easily (Wood, Mentzelopoulos, & Protopsaltis, 2015).

We have chosen Code combat for our study due to its programming language support in Python and its accessibility. Code combat provides free access for its first course. It also allows us to include all of our students in one class.

Evaluation Method

We incorporated Code combat in our Python programming subject for one class of IT students in October 2019. The class consisted of 26 students. The Code combat was introduced at the beginning of the semester, and the students were given one week to complete the game until level 18. The students needed to submit a proof of completion to get the mark for the subject.

To evaluate the effectiveness of the serious game to improve student's programming skills, we focus on three main criteria, namely: learning outcome, game feedback and overall game experience. We then gathered the students' feedback from these criteria.

A. Learning Outcome

The learning outcome criterion is used to measure the impacts of a serious game to construct programming language solutions through multi-level game challenges. At the beginning of the game, the students would be given easy problems to start creating programming solutions. The complexity and difficulty level would be gradually increased. It allows the students to step-by-step increase their problem solving, analytical thinking, logical and reasoning, programming planning, programming conceptual understanding, and algorithmic skills.

This criterion was evaluated using pre- and post-game-session tests. We used the same questions in the pre and post-tests. This test has eight questions to assess the students' understanding of Python programming. The items are shown in Table 1.

Table 1. Questions for pre and post-game session tests

No	Question
1	How to put a string argument when calling a function?
2	How to assign a variable in Python?
3	How to write a line of comment in Python?
4	How to call a function without any argument?
5	How to save a value from a function in a variable in Python?
6	How to pass an integer argument when calling a function?
7	How to write a while loop in Python?
8	How to pass two arguments when calling a function?

Before the students played the game, the pre-game session test was conducted. The post-game session test was done after the students submitted proof of game completion. We received 19 valid responses from the students for both tests.

B. Game Feedback

The game feedback criterion is used to measure sufficient individual-feedback given to the students during the game session. It is also used to measure the impacts of that feedback to improve the student's programming skills. Inside the game environment, individual feedback is provided in case of errors. The visual output of the game state is provided through the motion/interaction in the game itself.

To evaluate this criterion, we developed a survey comprising six items regarding the game feedback. We also added one item to assess if the students learn new programming skills in the game. The summary of these questions is shown in Table 2. The survey uses a 5-point Likert scale, with 5 as strongly agrees, and 1 as strongly disagrees.

Table 2. Survey for Game Feedback

No	Item	Category
1	The code lines and feedback in the game are easy to use.	Feedback
2	The goal of the game is clearly defined.	Feedback
3	The rules and rules and the codes in the game are easy to understand.	Feedback
4	I was aware of how I was performing in the game.	Feedback
5	I knew what I wanted to do and achieve.	Feedback
6	I felt in total control of my playing actions.	Feedback
7	I gain new skills by playing the game.	New Skill

The survey was distributed after the submission of proof of game completion. We received 19 valid responses from the students.

C. Overall Game Experience

The game experience criterion is used to measure the ability of the game to create an enjoyable learning environment for the students. It was evaluated using a survey and written feedback. The survey comprises seven items in three categories, namely: motivation, positive experience and negative experience. Similar to the game feedback criterion survey, the survey uses a 5-point Likert scale, with 5 as strongly agrees and 1 as strongly disagrees. The summary of these questions is shown in Table 3. In addition to the survey, we also gathered written feedback from the students. We used this feedback to assess the students' experience of the game.

Table 3. Survey for Overall Game Experience

No	Item	Category
1	I was challenged, but I believed my skills would allow me to meet the challenge	Motivation
2	The game motivates me to learn and/or discuss with others	Motivation
3	The game session was fun	Positive
4	I want to play the game again	Positive
5	I am interested in the game content	Positive
6	The game was boring	Negative
7	I did not learn anything from the game	Negative

The survey was distributed after the submission of proof of game completion. We received 19 valid responses from the students.

Findings

The summary of the findings is organised based on the three main criteria evaluated.

A. Learning Outcome

The summary of results from the pre- and post-game session tests is shown in Table 4. Table 4 shows that the number of students that answer the question correctly in the post-test is higher than the number of students in the pre-test. It is true except for question 8, which the number is the same. The average percentage of increment is 16.45. It indicates that on average, 3 out of 19 students were able to improve their programming skills.

Table 4. Pre and Post Test Results

Question No	Number of correct answers		Increment (%)
	Pre-Test	Post-Test	
1	11	14	15.79
2	12	15	15.79
3	15	17	10.53
4	15	17	10.53
5	11	16	26.32
6	10	16	31.58
7	15	19	21.05
8	18	18	0.00
Average	13.37	16.50	16.45

B. Game Feedback

Based on the valid responses for game feedback survey, we illustrate the findings in Figure 1. Figure 1 shows that the students' average scores for all the items in the survey are above 4. The overall average from all the seven items is 4.4. The results suggest that the students' find the feedback in the game is appropriate or helpful.

Figure 1. Game Feedback Survey Results

The correlations between the game feedback with the new programming skills that the students learnt were calculated using Pearson's correlation. The results are summarised in Table 5. The results show a significant relationship between item 1 (the code lines and feedback in the game are easy to use) with the new programming skills that the students learnt ($p<0.05$). While the other items do not have significant influence ($p> 0.05$). It indicates that game feedback that provides codes related to specific programming topics helps the student to learn new programming skills.

Table 5. Linear Regression Results on the Correlation between Game Feedback and New Skills Learnt

Item	Coefficient
1. The code lines and feedback in the game are easy to use.	0.465*
2. The goal of the game is clearly defined.	-0.007
3. The rules and rules and the codes in the game are easy to understand.	-1.306
4. I was aware of how I was performing in the game.	0.072
5. I knew what I wanted to do and achieve.	0.362
6. I felt in total control of my playing actions.	0.372

* $p < 0.05$

C. Overall Game Experience

Based on the survey results, the summary for the overall game experience is shown in Figure 2. The results show that the average scores for the motivation and positive experience are above 3.9. And the average score for negative experience is below 1.8. The score indicates that the students have an excellent experience with the game. It also suggests that the game can help motivate the students to learn new programming skills.

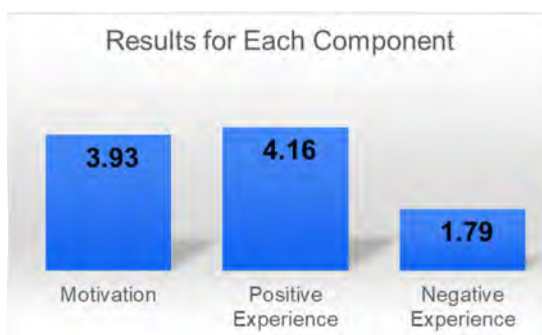

Figure 2. Overall Game Experience Results

Other than the survey, we also collected written feedback from the students. We applied sentiment analysis method, which has been widely used to study opinions, sentiments and emotions expressed in texts (Miner, et al., 2012), to analyse the written feedback. The sentiment analysis can be used to identify positive or negative opinions based on a set of the positive and negative lexicon. The average score from the written feedback is 0.684. The sentiment analysis score suggests a positive game experience as the score is above 0.

Discussion

For the learning outcome criterion, the results show an increment on the number of correct answers in the post-game session test. It indicates that the students can absorb new programming skills by playing this game. With the multi-level stories and scenarios, the game helps the students to gradually increase their problem solving, analytical thinking, logical and reasoning, programming planning, programming conceptual understanding, and algorithmic skills to complete the game. The students spend hours to play the game and voluntarily learn new programming skills.

The game feedback results show that the students find the feedback in the game is suitable for individual feedback. The correlation results also show a significant correlation between Item 1 and new programming skills learnt by students. It indicates that the game provides sufficient individual-feedback that helps the students to learn new programming skills. Both survey and written feedback for overall game experience also show that the students have a pleasant experience using the game.

Based on the results for these three evaluation criteria, we learnt that serious game could reduce the two main challenges that the students encounter in computer programming subjects. The game helps the students to bridge the problem solution construction and programming language construction by providing multi-level stories and scenarios. It allows students to learn and gain new programming skills gradually. The game also includes individual-feedback that would help the students to understand their mistakes in the game environment. These results provide a strong indication that serious game can be used as an alternative tool to learn programming skills.

Conclusion

Two main challenges in learning programming skills are (1) difficulty in bridging the problem solution construction and programing language construction, and (2) insufficient individual-feedback. We explore the use of the serious game as an alternative approach to tackle these challenges. We incorporated one off-the-shelf serious game for Python programming in one computer programming subject for one class of IT students in Temasek Polytechnic. We then evaluated its effectiveness in three main criteria, namely: learning outcome, feedback and game experience.

We gathered students' feedback in forms of pre- and post-game session tests, surveys and written feedback. The results indicate that the game helps the students to gradually construct their programming skills using the multi-level stories and scenarios and individual-feedback. The results also show that the serious game is highly accepted by the students to deepen their understanding of specific concepts in programming.

Nonetheless, we see two possible extensions that we would like to study in the near future. First, we would like to explore more detail about the impact of multi-level scenario to the students' learning. We would like to evaluate the students' progress in each level and analyse how the students make the decision in the game. It would require us to collect more detail game data. Second, we would like to explore the possibility of providing "real-time" students' progress to the lecture. This information would help the lecturer to provide additional scaffolding for a particular group of students.

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LEARNING ENGLISH THROUGH MASTERPIECES OF MUSIC
--- Practical Report on a Class Activity Utilizing Songs ---

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Abstract

This is a practical report on an active listening and singing activity utilizing songs, which is named *Meikyoku-eigo* in Japanese, Learning English through Masterpieces of music, as a literal translation. In 60 to 90-minute lesson, after an introduction of a song and a singer, students tackle a listening task. They work on it in groups, changing the members one after another, in an active learning style. The group members are encouraged to help each other to fill in all the blanks in the sheet. Then they read the lyrics aloud several times in choral reading, simultaneous reading and shadowing, etc., and finally the students try their best to sing the song together at the end of the lesson. The introduced song is going to be sung in the subsequent classes, as a warm-up activity at the beginning of each class. The students are encouraged to sing even outside of class, which might be a good reading and speaking practice. Also, the coming exam covers the handouts used in the lesson as one of the materials. A questionnaire was conducted on 301 students in 2018. The result shows that the students enjoy the activity a lot [4.37 /5], find it worthwhile [4.4] and 84% of the students have experience of singing the song outside of class, which gives statistic basis for continuing this activity. They like new, loud and fast songs than old, quiet and slow ones, and the most preferred songs in 11 songs they had sung by the time of the survey were "You Belong with Me" (Taylor Swift, 2009) and "Sugar" (Maroon5, 2014) with the same point [4.35], followed by "Story of My Life" (One Direction, 2013) [4.26] and "Just the Way You Are" (Bruno Mars, 2010) [4.16]. The students left quite a few of positive comments such as "This is the most effective listening lesson." "I have learned linking of words." "I want to sing more songs." "I am always looking forward to this. Please continue." and requests for improvement, "Increase the score ratio in the test." "Fast parts are difficult to sing."

Keywords: *English education, listening, reading aloud, group learning, task-based learning*

1. Background of the study

Songs are long made use of at a variety of situations in English education. Effectiveness of using songs in English class is reported in various forms, for example, the books written by Nakashima (2000), Inoue et al. (2008), and Kashiwagi (2010), and also papers by Kobayashi (2003) and Sekido (2016), as practical reports at colleges.

With that background, the author himself has long used songs as one of the class activities, has improved little by little, and currently the students learn four songs a year, in an activity named "*Meikyoku-eigo*," Learning English through Masterpieces of music, as a literal translation. The students sing the song they learn in *Meikyoku-eigo* at the beginning of the class afterward as a warm up, and the lyrics of the song will be one of the materials for the coming exam.

2. Objectives of "*Meikyoku-eigo*"

There are three objectives in *Meikyoku-eigo*.

(1) To give students opportunities for being exposed to English and its cultures

Meikyoku-eigo can be a good opportunity for students to come in touch with not only the lyrics of the songs but also the cultures behind them. Some songs have promotion videos as drama style, for example, the video of "You Belong with Me" by Taylor Swift is just like a teen romance movie.

(2) To inspire students' interest in English

By introducing material in the form of music, the author intends to inspire students' interest in English more. Learning English through music is easy to approach, and in addition, words and phrases used in the lyrics are considerably different from the ones in textbooks, which look fresh and attractive to students. Even students who are not necessarily motivated in studying English tend to practice hard because they want to sing the song well.

(3) To promote English learning outside of class

Even students who are reluctant to study English at home can cope with singing English songs easily and enjoyably. In fact, there are always several students who sang the introduced songs with friends at karaoke, when I ask after long holidays.

3. Contents of the *Meikyoku-eigo* and related activities

Contents of *Meikyoku-eigo* which serves as an introductive activity, warm-up singing at the beginning of the classes and evaluation at mid-term and term exams are described below.

3.1. Contents of the *Meikyoku-eigo* activity

Usually, at the first class after mid-term and term exam, a new song which students are going to sing afterwards is introduced with YouTube video and PowerPoint slides. It takes approximately 60 minutes. This introductive activity is actually called *Meikyoku-eigo*, and consists of six subdivided activities.

[Activity 1] Meaning and objectives of *Meikyoku-eigo*

The author always explains why we do this activity and what effects are expected at the beginning of each *Meikyoku-eigo*. As students have tendency not to tackle a task eagerly without understanding the objectives and effects, I have my students confirm them every time. I tell them ten effects described below, referring to Yasukouchi (2015). I know some of them are a little exaggerated and distorted but that is just for persuading the students to attend the activity more enthusiastically.

1. Listen to a song carefully and repeatedly = Intensive listening
2. Listen to a song without paying attention = Extensive listening, Scanning
3. Fill in the blank sheet = Dictation (Becoming aware of phonetic phenomenon, such as linking, weak forms etc.)
4. Think about the meanings and sentence structures = Learning grammar, words and phrases
5. Listen to a song with lyrics sheet = Rapid reading
6. Listen and understand = Understand English without intervention of Japanese
7. Practice singing a song with a lyric sheet = Overlapping
8. Practice singing a song without a lyric sheet = Repeating, shadowing
9. Sing a song at karaoke = Reading aloud
10. Learn lyrics by heart and sing = Recitation, presentation

[Activity 2] First listening

Students listen to a new song and get to know what is the song like. Usually, I show them a YouTube video.

[Activity 3] Information about the song and the singer

Teacher gives information about a song and a singer. As for a singer, background information such as origin, years active, all the members name if it is a band, other hit songs, interesting episodes and so on are given. For example, about One Direction, I told that they were originally born out of an audition show, the annual income of 2015 was said to be $130 million, and the ex-girlfriend of Harry Styles, one of the members, was Taylor Swift. As for information about a song, when the song was released and the highest ranking etc. are informed. In my experience, the students tackle the tasks and sing more eagerly when they know the background information about the song and the singer.

[Activity 4] Listening task

Students listen to the song and fill in the blanks in a lyric sheet. Usually, there are 20 to 30 blanks in the sheet and students listen four to six times depending on the difficulty level. They work on it in groups, changing the members one after another, in an active learning style. The group members are encouraged to help each other to fill in all the blanks in the sheet.

[Activity 5] Practice reading the lyrics

Students read the lyrics aloud several times in choral reading, simultaneous reading and shadowing, etc. in order to get ready to sing the song aloud.

[Activity 6] Singing together

Finally, students try their best to sing the song together. However, as they are not fully familiar with the song, they tend not to sing it in a loud voice. At this stage, I never force them to sing aloud, but just tell them to listen and sing a few times at home and be ready for singing in the next lesson.

3.2. *Meikyoku-eigo* as a warm-up activity

The introduced songs are going to be sung in the subsequent classes, as a warm-up activity at the beginning of each class. After practice reading the lyrics briefly as a review, students sing the song usually twice while sitting. Then, they stand up and try to sing louder one more time. I sing together twice, but at the third time, just listen to the students sing, and give them a brief review about their singing, mostly positive comments. As students not only become familiar with the song little by little, but also practice singing even outside of class, teacher can recognize their progress every time he/she hears it. In consideration of students who are not fond of singing, teacher should not force students to sing in a loud voice, but allow them to “whisper” or “murmur” it. Also, teacher should try his/her best to enjoy singing together to create an easy to sing atmosphere in the classroom.

3.3. Evaluation in exams

Midterm and term exams cover the handouts used in the lesson as one of the materials. Questions asked in exams are generally simple, such as fill in the blanks with proper words. Sometimes the first spellings of the words are given or sometimes students choose the appropriate verbs from the options and conjugate them if necessary.

The questions are generally not so difficult, which students can answer easily if they sing steadily in the classes, and I believe this motivate them to sing more.

4. Questionnaire survey

A questionnaire was conducted on 301 students in 2018 to know the evaluation of *Meikyoku-eigo* by the students and get some suggestions to improve the activity.

4.1. Details of the survey

Implementation date: October, 2018
Survey participants: Second and third-year students in National Institute of Technology, Kitakyushu College (n=301)

4.2. Questionnaire

The questionnaire consists of six categories shown below. Categories (1) to (3) are Likert five or four-point scale, (4) is two-point, and (5) and (6) are free description.

(1) Evaluation of *Meikyoku-eigo*
  1. I enjoy *Meikyoku-eigo*.
  2. I work on *Meikyoku-eigo* positively.
  3. *Meikyoku-eigo* is a good activity.
  4. I have sung *Meikyoku-eigo* song outside of class.

(2) Evaluation of each activity in *Meikyoku-eigo*
  1. Information about the song and the singer
  2. Listening task
  3. Singing together

(3) Evaluation of the introduced songs
  1. “Sesame Street Opening Theme”
  2. “Sakura” (Moriyama Naotaro)
  3. “You Belong with Me” (Taylor Swift)
  4. “Story of My Life” (One Direction)
  5. “Let It Be” (The Beatles)
  6. “Perfect” (One Direction)
  7. “Wherever You Are” (ONE OK ROCK)
  8. “Sugar” (Maroon 5)
  9. “Remember Me” (Miguel)
  10. “Just the Way You Are” (Bruno Mars)
  11. “Nandemonaiya” (Radwimps)

(4) What kind of song do you want to sing?
  1. New or Old
  2. Cheerful or Gentle
  3. Fast or Slow

(5) Any song or singer you want to sing

(6) Any question or suggestion

5. Results and Discussion

In this section, I will discuss only significant features using graphs. The overall aggregate results are shown in Appendix 1.

5.1 Evaluation of *Meikyoku-eigo*

The average score for “1. I enjoy *Meikyoku-eigo*”, 4.37 out of 5, was extremely high. The number of students who answered "very enjoyable" was 150, and with only one and five students answered "not much" and "not at all" respectively. This result gave me courage to continue the activity in the future. (See Figure 1)

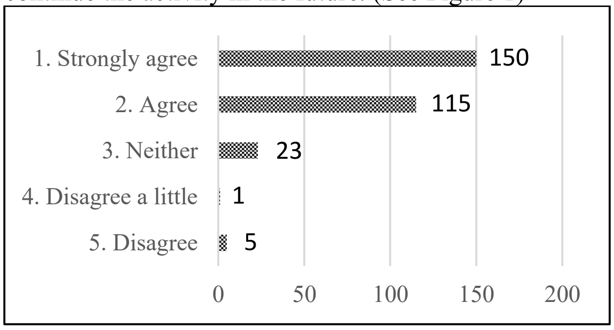

Figure 1. I enjoy *Meikyoku-eigo* (4.37/5)

As for “3. *Meikyoku-eigo* is a good activity”, the average score of 4.4 was even higher. The students not only had fun, but they also realized a variety of benefits which will be described later at 5.3 Comments, questions or suggestions. (See Figure 2)

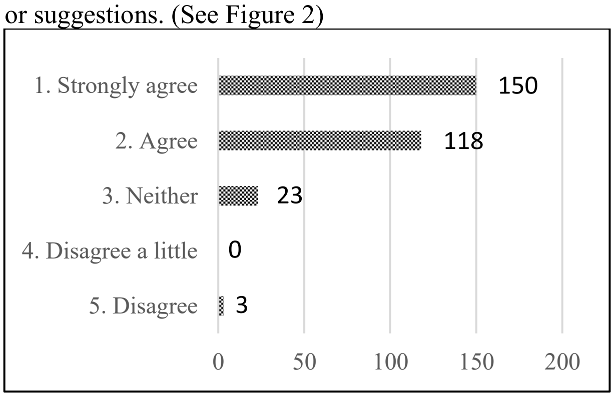

Figure 2. *Meikyoku-eigo* is a good activity (4.4)

When asked "4. I have sung *Meikyoku-eigo* song outside of class", 84% of the students had sung. It is a great achievement that I was able to give technical college students, who tend to be lacking in English learning outside the college, an opportunity to come into contact with English. (See Figure 3)

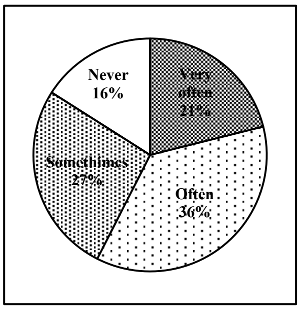

Figure 3. I have sung *Meikyoku-eigo* song outside of class (84%)

5.2 Evaluation of the songs sung in *Meikyoku-eigo*

I aggregated the data after quantifying "very good" to 2, "good" to 1, "neither good nor bad" to 0, "not very good" to -1, and "not good" to -2. The top five songs, "You Belong with Me" (Taylor Swift, 2009), “Sugar”

(Maroon 5, 2015), "Story of My Life" (One Direction, 2013), "Just the Way You Are" (Bruno Mars) and "Perfect" (One Direction) are all new and uplifting. I would like to refer this result for the future song selection. (See Figure 4)

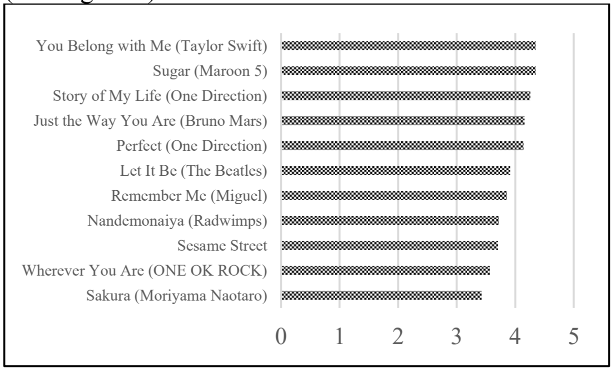

Figure 4. Evaluation of the songs

5.3 Favorite type of song

The result shows that the students prefer new songs to old songs, cheerful songs to quiet songs, and fast songs to slow songs. I know some teachers who want their students to listen to old songs, specifically, the songs they liked when they were young. We should not forget, however, songs popular now are going to be the memorable songs for our students in the future. My experience is that when I choose the latest songs, students tackle activities more eagerly, and sing more cheerfully. (See Figure 5)

1. New song	2. Old song
198	90
1. Cheerful	2. Gentle
214	72
1. Fast	2. Slow
170	116

Figure 5. Favorite type of song

5.3 Comments, questions or suggestions

Some of the positive comments included the followings.

My awareness for English songs has increased.
I have learned linking of English words.
It's so much fun and I'm looking forward to it every time. Please continue.
It's fun and relieves stress.
I think it's very good that I don't have to suffer to study English.
During this activity, it is easy to learn words, grammar, etc.
It's a lot of fun because we do a lot of different activities.
I want to sing more songs.
This is the most effective listening lesson.
I've wanted to do this since I was in junior high and elementary school.
Please let more people know about this activity.

There were a number of other positive comments. They also provide a rationale for continuing this activity.

The followings are opinions for improvements.

I want to sing till the end.
Fast parts are difficult to sing.
Singing is fine, but I don't like to be made to stand up.
Don't include words we haven't learned in parentheses in fill-in-the-blank sheet.
Increase the score ratio in the test.

The first opinion is about the fact that the students used to sing only the first 2 or 3 minutes of the song because it would take too long if we sang all the song all the time. Now, I have changed to letting the students sing till the end when the students stand up and sing, at the third time singing. As for the second opinion, I had noticed before the survey that there were students who were mumbling at the fast-singing parts, so the students now practice intensively the fast parts before start singing. As for the fifth one, the current percentage of *Meikyoku-eigo* in test scores is about 15%, which is considered reasonable in light of the balance in English classes as a whole, but I would like to try increasing this to about 20% in the hope that it will motivate students more.

6. Summary and future prospects

The survey showed that the students "really enjoy *Meikyoku-eigo*" and "think that Meikoyku-eigo is a very good activity", which gives me a rationale for continuing this activity in the future. One of the comments was, "Please let more people know about this activity." In accordance with this comment, I would like to actively give presentations at seminars and conferences so that *Meikyoku-eigo* can spread as widely as possible.

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Appendix 1. Results of *Meikyoku-eigo* questionnaire survey (October, 2018, Second and third-year students in National Institute of Technology, Kitakyushu College, n=301)

(1) Evaluation of Meikyoku-eigo	1. Strongly agree	2. Agree	3. Neither	4. Disagree a little	5. Disagree
1. I enjoy Meikyoku-eigo.	150	115	23	1	5
2. I work on Meikyoku-eigo positively.	122	134	33	2	2
3. Meikyoku-eigo is a good activity.	150	118	23	0	3
	Very often	Often	Somethimes	Never	
4. I have sung Meikyoku-eigo song outside of class.	62	107	78	47	
(2) Evaluation of each activity in Meikyoku-eigo	1. Excellent	2. Good	3. Neither	4. Average	5. Poor
1. Information about the song and the singer	106	139	44	2	3
2. Listening task	124	134	27	6	2
3. Singing together	148	121	20	0	4
(3) Evaluation of the introduced songs	1. Excellent	2. Good	3. Neither	4. Average	5. Poor
1. “Sesame Street Opening Theme”	21	36	26	5	4
2. “Sakura” (Moriyama Naotaro)	13	37	24	10	7
3. “You Belong with Me” (Taylor Swift)	45	33	13	0	0
4. “Story of My Life” (One Direction)	37	39	14	0	0
5. “Let It Be” (The Beatles)	24	40	23	3	1
6. “Perfect” (One Direction)	33	41	15	1	1
7. “Wherever You Are” (ONE OK ROCK)	25	27	22	9	8
8. “Sugar” (Maroon 5)	45	36	8	1	1
9. “Remember Me” (Miguel)	74	133	61	15	8
10. “Just the Way You Are” (Bruno Mars)	118	120	39	9	5
11. “Nandemonaiya” (Radwimps)	86	105	52	24	22

A Comparison Table to “Model Core Curriculum”: A Criteria of English Learning at National Institute of Technology (KOSEN)

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Abstract

Considering the standardization in education at National Institute of Technology (KOSEN), there is the important common curriculum, “Model Core Curriculum (MCC)” applied to all 55 colleges. In this paper, we aim to make a comparison table to MCC in English learning at KOSEN.
Based mainly on our promoting active learning (AL) in English subjects, according to main objectives of MCC, we sorted out our learning practices into the following main four categories: (1) the nurture of autonomy, (2) the use of ICT, (3) the collaborative learning of English and specialized subjects, and (4) the establishing of learning authenticity. Satisfying the need for the above (1), we offered our students the learning opportunities of presentation and PBL associated with their speciality. As the result, we completed such notable achievements as the winning of “The Minister of Education, Culture, Sports, Science and Technology's Award”. As to the above (2), we proved afterschool activities as a method were effective in which a group of students voluntarily developed an application software for English learning based on their speciality. Under the achievements of the above (1) and (2), we have designed a suitable curriculum for KOSEN students to be categorized as the above (3). As a major part of our presentation, we plan to show our curriculum design for English learning under the light of MCC.
However, we admit there is an issue to be addressed in our curriculum design. It is the mapping out of the various certificate examinations such as TOEIC®, “English Technical Writing Test” and so forth. In Japan, these tests are highly esteemed, and the scores can be widely used as securing objectivity. In fact, for passing “Institutional Certified Evaluation and Accreditation”, we often present students’ scores as valid evidence for our teaching effectiveness. Presently many KOSEN students take those tests, but it is difficult to conclude whether such tests are suitably placed in our curriculum design. MCC doesn’t mention the certificate examinations directly. Nevertheless, we need to fill the gap between the above (1) ~ (4) and the encouragement of those certificate examinations under the comparison with MCC.

Keywords: *English Language Learning, Model Core Curriculum (MCC) at KOSEN, Active Learning(AL), Nurturing Global Engineers, Liberal Arts Education*

(I) Introduction

For KOSEN (NIT: National Institute of Technology), there is the important common curriculum, “Model Core Curriculum (MCC)” applied to all 55 colleges. However, regarding of the present situation of English learning in Japan, TOEIC (a English proficiency test) is highly esteemed, and the scores can be widely used as securing objectivity. In fact, for passing “Institutional Certified Evaluation and Accreditation”, we often present students’ scores as valid evidence for our teaching effectiveness. Presently many KOSEN students take TOEIC test, but it is difficult to conclude whether such tests are suitably placed in MCC curriculum design. MCC doesn’t mention the certificate examinations directly. Nevertheless, especially for KOSEN students, we need to fill the gap between MCC and the encouragement of TOEIC certificate examinations under the comparison with MCC.

(II) Materials: “Model Core Curriculum (MCC)”: the superior originality of education at KOSEN

MCC is the educational object and goal set for all KOSEN students. It mainly consists of the two categories: “core” and “model”. The former, core is the general learning contents which KOSEN students should acquire. The latter, model is based on the core, and shows KOSEN students the learning contents at higher levels. Classified with subjects, the core part contains the fundamental and general subjects such as mathematics physics or English. As the other characteristic in the core, experiments or practical training is also included. Skills as engineers for general purpose are categorized as this section. Reinforcing the core curriculum, "model" includes the competency covering cross fields, in which generic skills, attitude and intentionality concerning human nature, and comprehensive learning experience and creative thinking are included. Furthermore, each NCT college can develop its original creative curriculum based on this model core curriculum which each NCT uses to give students the particular opportunity to learn regional problems under the common curriculum. This model core curriculum means the double learning by which each NCT college has freely to choose its own curriculum to some extent. This enables each NCT campus to have independency. One of the main reasons is that NCT highly depends on the local circumstances.

Figure 1. The Outline of MCC

Next, we explain the contents of English learning in MCC.

MCC clearly stresses some of the key issues in English learning. It tells as follows:

> To improve English faculty, the correlation between English subject and the other ones and the creation of "actual opportunity for using English are important. For example, constructing theoretical writing such as paragraph writing has a common ideal with which English learning can be corroborated with other subjects such as Japanese and history.

Three categories are given to the English learning: first, MCC stresses the basic skills as a basis for English proficiency. Next, it does the foundation of the basic skills, and finally the learning English aiming for improvement of English proficiency.

MCC for English learning can be said to be well balanced. As a main reason of it, in MCC, an important keyword "English Communication" is set, and a variety of learning material are referred. Presentation, discussion ICT are mainly fit to this objective of learning. Considering the guideline issued by the ministry of education, MCC is useful and suitable for KOSEN.

We have developed our learning English curriculum based on MCC. However, here, we faced one big problem. It is the need to balance between English proficiency test (TOEIC) and practical learning programme such as English presentation, PBL and so on.

Ⅲ-B 英語

	モデルコアカリキュラム	高等学校学習指導要領
目標	【本科における教育領域の到達目標】 ・英語運用の基礎となる知識や技能を習得し、実際の場面での英語の使用に役立てることができる。（1～5年次） ・相手と英語でコミュニケーションを図ろうとする態度や異文化を理解しようとする姿勢を身に付け、実際の場面での英語の使用に役立てることができる。（1～5年次） ・日常生活や自分の身近なことについて、ある程度の的確さ、流暢さ、即応性をもって内容を聴解、読解、伝達できる。（1～3年次） ・社会性のある話題や自分の専門に関する基本的な情報や考えについて、内容の聴解、読解、伝達に加え、簡単な意見交換ができる。（3～5年次）	外国語を通じて、言語や文化に対する理解を深め、積極的にコミュニケーションを図ろうとする態度の育成を図り、情報や考えなどを的確に理解したり適切に伝えたりするコミュニケーション能力を養う。

		モデルコアカリキュラム・学習内容の到達目標	高等学校学習指導要領
英語運用の基礎となる知識	発音	・聞き手に伝わるよう、句・文における基本的なリズムやイントネーション、音のつながりに配慮して、音読あるいは発話できる。	第1 コミュニケーション英語基礎 1 英語を通じて、積極的にコミュニケーションを図ろうとする態度を育成するとともに、聞くこと、話すこと、読むこと、書くことなどの基礎的な能力を養う。 2 (1) 1の目標に基づき、中学校学習指導要領第2章第9節の第2の2の(1)に示す言語活動を参照しつつ、適切な言語活動を英語で行う。
		・明瞭で聞き手に伝わるような発話ができるよう、英語の発音・アクセントの規則を習得して適切に運用できる。	第1 コミュニケーション英語基礎 2 (2) (1)に示す言語活動を効果的に行うために、それぞれの生徒の中学校における学習内容の定着の程度等を踏まえた上で、中学校学習指導要領第2章第9節の第2の2の(2)のアに示す事項を参照しつつ、適切に指導するよう配慮するものとする。
	語彙	・中学で既習の語彙の定着を図り、高等学校学習指導要領に準じた新出語彙、及び専門教育に必要となる英語専門用語を習得して適切に運用できる。	
	文法及び構文	・中学で既習の文法や文構造に加え、高等学校学習指導要領に準じた文法や文構造を習得して適切に運用できる。	
英語運用能力の基礎固め	英語コミュニケーション	・日常生活や身近な話題に関して、毎分100語程度の速度ではっきりとした発音で話された内容から必要な情報を聞きとることができる。	第2 コミュニケーション英語Ⅰ 1 英語を通じて、積極的にコミュニケーションを図ろうとする態度を育成するとともに、情報や考えなどを的確に理解したり適切に伝えたりする基礎的な能力を養う。 2 (1) 生徒が情報や考えなどを理解したり伝えたりすることを実践するように具体的な言語の使用場面を設定して、次のような言語活動を英語で行う。 ア 事物に関する紹介や対話などを聞いて、情報や考えなどを理解したり、概要や要点をとらえたりする。
			第3 コミュニケーション英語Ⅱ 2 (1)ア 事物に関する紹介や報告、対話や討論などを聞いて、情報や考えなどを理解したり、概要や要点をとらえたりする。
		・日常生活や身近な話題に関して、自分の意見や感想を基本的な表現を用いて英語で話すことができる。	第2 コミュニケーション英語Ⅰ 2 (1)ウ 聞いたり読んだりしたこと、学んだことや経験したことに基づき、情報や考えなどについて、話し合ったり意見の交換をしたりする。 第3 コミュニケーション英語Ⅱ (1)ウ 聞いたり読んだりしたこと、学んだことや経験したことに基づき、情報や考えなどについて、話し合うなどして結論をまとめる。
			第5 英語表現Ⅰ (1)ア 与えられた話題について、即興で話す。また、聞き手や目的に応じて簡潔に話す。
			第6 英語表現Ⅱ 2 (1)ア 与えられた条件に合わせて、即興で話す。また、伝えたい内容を整理して論理的に話す。
		・説明や物語などの文章を毎分100語程度の速度で聞き手に伝わるように音読ができる。	第2 コミュニケーション英語 2 (1) イ 説明や物語などを読んで、情報や考えなどを理解したり、概要や要点をとらえたりする。また、聞き手に伝わるように音読する。 第3 コミュニケーション英語Ⅱ 2 (1)イ 説明、評論、物語、随筆などについて、速読したり精読したりするなど目的に応じた読み方をする。また、聞き手に伝わるように音読や暗唱を行う。
		・平易な英語で書かれた文章を読み、その概要を把握し必要な情報を読み取ることができる。	
		・日常生活や身近な話題に関して、自分の意見や感想を整理し、100語程度のまとまりのある文章を英語で書くことができる。	第2 コミュニケーション英語Ⅰ 2 (1)エ 聞いたり読んだりしたこと、学んだことや経験したことに基づき、情報や考えなどについて、簡潔に書く。
			第5 英語表現Ⅰ 2 (1) イ 読み手や目的に応じて、簡潔に書く。

Figure 2. An Outline of English learning in MCC

		・母国以外の言語や文化を理解しようとする姿勢をもち、実際の場面で積極的にコミュニケーションを図ることができる。	第1 コミュニケーション英語基礎 1 英語を通じて、積極的にコミュニケーションを図ろうとする態度を育成するとともに、聞くこと、話すこと、読むこと、書くことなどの基礎的な能力を養う。
			第2 コミュニケーション英語Ⅰ 1 英語を通じて、積極的にコミュニケーションを図ろうとする態度を育成するとともに、情報や考えなどを的確に理解したり適切に伝えたりする基礎的な能力を養う。
			第3 コミュニケーション英語Ⅱ 1 英語を通じて、積極的にコミュニケーションを図ろうとする態度を育成するとともに、情報や考えなどを的確に理解したり適切に伝えたりする能力を伸ばす。
			第5 英語表現Ⅰ 1 英語を通じて、積極的にコミュニケーションを図ろうとする態度を育成するとともに、事実や意見などを多様な観点から考察し、論理の展開や表現の方法を工夫しながら伝える能力を養う。
		・実際の場面や目的に応じて、基本的なコミュニケーション方略（ジェスチャー、アイコンタクト）を適切に用いることができる。	第7 英語会話 2 (2)ウ ジェスチャーなどの非言語的なコミュニケーション手段の役割を理解し、場面や目的に応じて適切に用いること。
英語運用能力向上のための学習	英語コミュニケーション	・自分の専門分野などの予備知識のある内容や関心のある事柄に関する報告や対話などを毎分120語程度の速度で聞いて、概要を把握し、情報を聞き取ることができる。	第4 コミュニケーション英語Ⅲ （1）1の目標に基づき、「コミュニケーション英語Ⅱ」の2の(1)に示す言語活動を更に発展させて行う。
		・英語でのディスカッション（必要に応じてディベート）を想定して、教室内でのやり取りや教室外での日常的な質問や応答などができる。	第6 英語表現Ⅱ 2. (1)エ 多様な考え方ができる話題について、立場を決めて意見をまとめ、相手を説得するために意見を述べ合う。
		・英語でディスカッション（必要に応じてディベート）を行うため、学生自ら準備活動や情報収集を行い、主体的な態度で行動できる。	
		・母国以外の言語や文化を理解しようとする姿勢をもち、教室内外で英語で円滑なコミュニケーションをとることができる。	第4 コミュニケーション英語Ⅲ 1 英語を通じて、積極的にコミュニケーションを図ろうとする態度を育成するとともに、情報や考えなどを的確に理解したり適切に伝えたりする能力を更に伸ばし、社会生活において活用できるようにする。
			第6 英語表現Ⅱ 1 英語を通じて、積極的にコミュニケーションを図ろうとする態度を育成するとともに、事実や意見などを多様な観点から考察し、論理の展開や表現の方法を工夫しながら伝える能力を伸ばす。
			第7 英語会話 1 英語を通じて、積極的にコミュニケーションを図ろうとする態度を育成するとともに、身近な話題について会話する能力を養う。
		・関心のあるトピックについて、200語程度の文章をパラグラフライティングなど論理的文章の構成に留意して書くことができる。	第6 英語表現Ⅱ 2. (1)イ 主題を決め、様々な種類の文章を書く。
		・関心のあるトピックや自分の専門分野のプレゼン等につながる平易な英語での口頭発表や、内容に関する簡単な質問や応答などのやりとりができる。	第5 英語表現Ⅰ ウ 聞いたり読んだりしたこと、学んだことや経験したことに基づき、情報や考えなどをまとめ、発表する。
			第6 英語表現Ⅱ 2 (1)ウ 聞いたり読んだりしたこと、学んだことや経験したことに基づき、情報や考えなどをまとめ、発表する。また、発表されたものを聞いて、質問したり意見を述べたりする。
		・関心のあるトピックや自分の専門分野に関する論文やマニュアルなどの概要を把握し、必要な情報を読み取ることができる。	第4 コミュニケーション英語Ⅲ （1）1の目標に基づき、「コミュニケーション英語Ⅱ」の2の(1)に示す言語活動を更に発展させて行う。
		・英文資料を、自分の専門分野に関する論文の英文アブストラクトや口頭発表用の資料等の作成にもつながるよう、英文テクニカルライティングにおける基礎的な語彙や表現を使って書くことができる。	第6 英語表現Ⅱ 2 (1)イ 主題を決め、様々な種類の文章を書く。
		・実際の場面や目的に応じて、効果的なコミュニケーション方略（ジェスチャー、アイコンタクト、代用表現、聞き返しなど）を適切に用いることができる。	第7 英語会話 2 (2)ウ ジェスチャーなどの非言語的なコミュニケーション手段の役割を理解し、場面や目的に応じて適切に用いること。

Figure 3. An Outline of English learning in MCC

(III) Methods: ICT and Presentation: English Learning Experience Needed for Global Engineers with KOSEN Brand

In this chapter, we discuss how English learning experience needed for nurturing global engineers should be obtained by KOSEN students. Mainly we will concentrate on the practice of ICT and presentation learning experience through English learning at KOSEN.

Generally speaking, in Japan, many English language teachers can say that it is difficult to promote KOSEN students' English autonomous learning experience. One main reason, we can point out, is that KOSEN students easily feel difficult to imagine how their English learning experiences would be useful to their future, especially in their workplaces. Therefore, English language teachers at KOSEN should be required to encourage KOSEN students to grasp the importance of their English learning experiences. Accordingly, we need to illuminate the way English learning experience can inspire students' academic interests. In this topic, our main points are as follows (1) ~ (3):

(1) HARAGUCHI and TAMURA focus on the efficiency of English presentation through English learning experience. In our research, 'the Project Based Learning (PBL)' teaching method is adopted. In this learning experience, students are required to form groups and deliver an English presentation promoting their own imagined local company to a target audience of foreigners.

(2) FUJITA, and MIYAMOTO maintain that the learning experience of technical English enables KOSEN students to seek their own identities as global engineers with KOSEN brand and helps to promote their career enhancements based on actual case studies. In this point, ICT learning by using Moodle for the 'English Technical Writing Test' is our main topics.

(3) NAKATSUKA demonstrates an application software he originally developed with other students. He was greatly inspired by the autonomous English learning. This can be good examples of active learning (AL) for KOSEN students.

As a main achievement, both a foreign student and NIT (KOSEN), Fukui College (TAMURA as the president) received prizes for distinct excellence from the Minister of Education, Culture, Sports, Science and Technology in March of 2019.

Keywords for this chapter are as follows: Nurturing Global Engineers with KOSEN Brand; English Learning Experience; Career Enhancement; Regional Activity; PBL; and Technical English.

As main methods, we demonstrate the following (i) ~ (iii):

(i) English Presentation Suitable for KOSEN Students

This method deals with the potential of learning to make English presentations for nurturing both global and local interests. In recent times, local contributions have become one of the most prominent objectives of higher educational institutes in Japan. In this learning experience, using PBL method, students are required to form groups and deliver an English presentation promoting their own imagined local company to a target audience of foreigners. This English learning experience is entitled 'Fukui to the World!', and so far introduced to about 300 students at NIT (KOSEN), Fukui College since 2015. Fukui is the name for a prefecture located in the middle part of Japan. Our aims are to bridge the considerable gap between KOSEN students English learning experience and the actual English use in their workplace, and to encourage KOSEN students to contribute as global engineers to their own local society: Fukui prefecture. This teaching method can be effective especially in using students' knowledge of ICT, expressing their interests in different cultures, and developing a business based in their home country. In short, this is an adequate learning opportunity for the "glocal (global and local)" mind-set, based on the technological skills that KOSEN students possess. As a part of our presentation, we will show some movies or sildes used in the best English presentation by two fifth graders, Ms Hina YAMANUKI and Yoshisada TAKEMURA. They exquisitely explained the skill of using chopsticks, especially useful for foreigners, and made a promotion movie video. Their presentation successfully displayed their own interest in locality and their creativity in the fields of engineering and marketing, as seen from the creativity in their original work: 'Pi:

Chopsticks for the World'. We analyse the excellent elements, drawing connections between creativity and their specialty as engineers

(ii) An Application Programme for Self-Study Created by Students

As second method, we introduce an example of students' autonomous ICT learning experience based on their specialities. NAKATSUKA is mainly engaged with this project.

This app created by them is aimed for self-study of technical English. It has 'four-choice questions' and 'fill-in-the- blanks questions with multiple choices'. Originally, it was supposed to be an app with only these two functions, but NAKATSUKA decided that additional functions should be created to develop the functions of dictionary or word lists for technical English.

NAKATSUKA used 'Android Studio' to develop this app. Android Studio is the official Integrated Development Environment (IDE) for Android app development based on IntelliJ IDEA. In addition to IntelliJ's powerful code editor and developer tools, Android Studio offers more features that enhance productivity for building Android apps.

Inspired by this English learning experience, NAKATSUKA uses his English skill very efficiently for his career enhancement by blending it with his engineering mind. This is a good example of English learning experience as a learning motivator for KOSEN students. As a part of our presentation, we will show a movie clip of this app made by NAKATSUKA.

(iii) Moodle Online Learning Experience for KOSEN Students

Developing Moodle learning course, FUJITA and MIYAMOTO mainly aim to construct the close relationship between ICT and English learning experience. This Moodle learning is at elementary level in which students' tasks can be automatically marked, and more than 80% was set as the required score for all 1st graders at NIT (KOSEN) Fukui College. Totally, the amount of work for teachers has been decreased. The followings (i) ~ (iii) are main features of this Moodle learning:

(i) Moodle can be a good drill learning, which doesn't need any paper.

(ii) Moodle can be learnt by students anywhere through using smart phone or PC.

(iii) In this Moodle, there is a 'question bank', from which teachers voluntary can choose any questions for making tests or tasks.

Thanks to this Moodle online English learning course, as already mentioned, NIT (KOSEN), Fukui College received prizes for distinct excellence (1st graders) from the Minister of Education, Culture, Sports, Science and Technology in March of 2019.

(iv) Analysis and Discussion of This Learning

As analysis and discussion of this learning conclusions, we propose two major points as follows:

(1) English proficiency tests like 'TOEIC®' or 'EIKEN®' are now very popular as English learning experiences in Japan; however, a collaboration of these tests and presentations or ICT learning experience can make for an ideal English learning.

(2) KOSEN students need to realise the importance of English language skills for them to become able global engineers. Although many agree that English learning is very important now and for the future, they need to understand that relevant autonomous learning experience should be included. As a result, English learning experience through making presentations and ICT are an efficient element of AL and PBL, wherein self-study by students should be essential.

Figure 4. 'Pi: Chopsticks for the World'

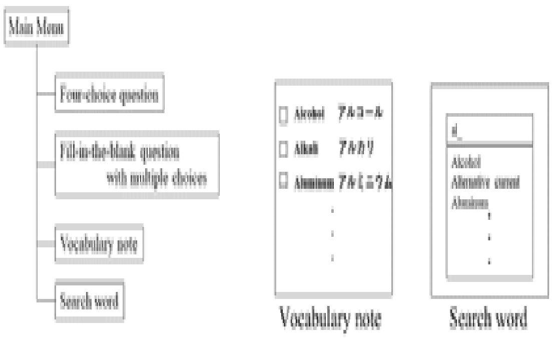
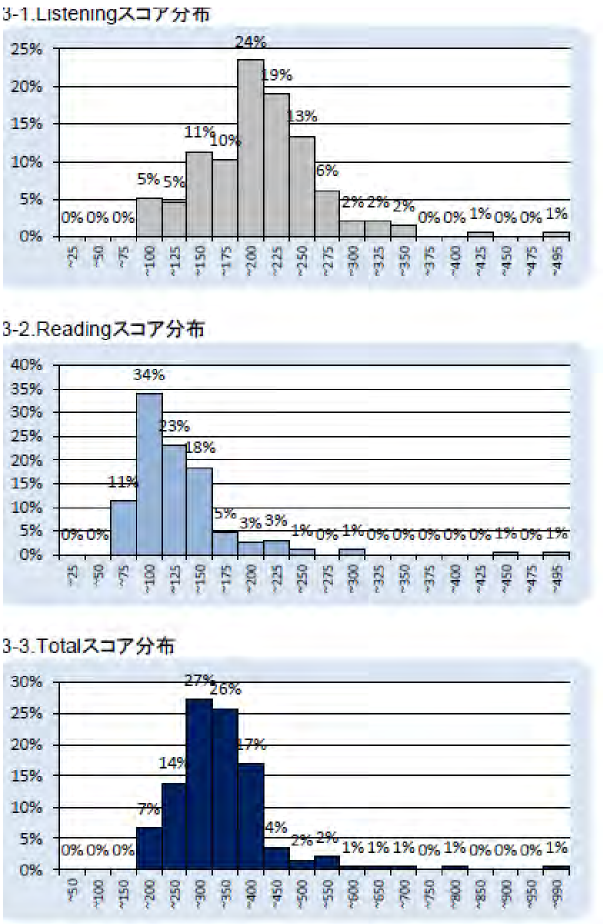


Figure 5. Application Programme for Self-Study of Technical English: Both of the figure 4 and 5 are created by students of NIT (KOSEN) Fukui College

(IV) Materials: A Results of TOEIC Score

In Japan, English proficiency test is highly valued as the very barometer for English learning. That is why we show the results of TOEIC score (2019) as follows:



n	mean	med	sd	max	min
204	332.3	330	88.43	755	40

Figure 6. TOEIC score in 2019

(V) Conclusions

In Japanese higher education system such as university or college, English learning can often be regarded as a part of general education. However, since introducing the so-called American style of liberal arts education just after the World War II, this method did not seem to produce great merits to both students and teachers in Japan. The main reason could be simple: such method, one-way style of teaching, can be difficult to attract students' learning motivation or their interests in learning itself. Especially, at KOSEN, the question about how to learn English effectively is gravely problematic. As a main factor, we point out that 'practicality' need to be pursued in English learning at KOSEN. In other words, English learning as a general subject tend to be easily regarded as 'unpractical'. To improve this circumstance, we try to design an ideal style of English learning at KOSEN, in which English learning experience at KOSEN can be thought as practical. The correlation between MCC curriculum and TOEIC (English Proficiency Test) could greatly contribute as to English learners' especially at KOSEN.

Acknowledgements

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Draft of next model core curriculum for promotion of information security education in KOSEN

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Abstract

KOSEN Security Educational Community (K-SEC) have promoted the education of highly-skilled experts in KOSEN. In this project, we have developed educational materials about information security and held various events to improve students' abilities. K-SEC will educate all KOSEN graduates to understand the basics about information security.

The model core curriculum (MCC) presents the core, which is the minimum level of proficiency and learning content that is aimed at reaching all students of KOSEN, and the model, which is a guideline for further upgrading education in KOSEN. For improvement of education in KOSEN, we have updated MCC every few years.

In order to realize the purpose of K-SEC mentioned at the beginning, it is indispensable to strengthen the section of information security in next MCC. To prepare a draft of the next MCC, K-SEC leaders selected important topics as skills map from curriculum standard by Information Processing Society in Japan. Then we commissioned an external organization to map the skills map and the abilities needed for the occupation of the graduate. Finally, we examined the goodness of fit in the mapping results and created the draft of the next MCC in section of information security.

We assume that KOSEN graduates will apply their knowledge on information security to be active as engineers. As part of their role, we suppose Point of Contact (PoC). It aims to mediate between engineers who are not familiar with information security and security experts inside and outside the organization, and the engineers who can respond appropriately to security incidents. Another role is supported to be Notification. We will educate engineers who can accurately contact to other sections and IT support desk when security incidents occur. The draft of the next MCC includes understanding information security principles, risk management, legal systems, etc.

We will promote education about information security to all KOSEN colleges based on the draft of the next MCC.

Keywords: *information security, curriculum, engineer, skills map, KOSEN*

Introduction

National Institute of Technology (hereafter, KOSEN) has been promoting the K-SEC project since 2016. In the K-SEC project, we are conducting various activities to cultivate students with advanced cybersecurity skills and to graduate with security skills in all students regardless of their specialty. The K-SEC project has two goals, taking advantage of KOSEN's strength of being able to continue education for five years from the age of 15. One is to educate students with outstanding cybersecurity technology. To educate very few experts who have acquired the advanced technology required as an information security expert. Furthermore, students who are majoring in the field of information technology will learn the security technologies that information engineers should have. These students account for about 20% of the total. Secondly, we are planning to make all students acquire the cybersecurity technology that engineers in all fields should acquire. All graduates are expected to acquire security skills and play an active role in society, together with their specialized fields. In order to achieve the above-mentioned objectives, the K-SEC project has been developing educational equipment, preparing teaching materials, conducting research on faculty, and providing technology in cooperation with other institutions.

This paper is about the development of an educational system for students in all fields. KOSEN provides the minimum level of proficiency and learning contents that are the goal of reaching all students, and guidelines for further upgrading colleges of technology. This is named MCC. All KOSEN conduct education according to the

MCC and add subjects to take advantage of the locality and characteristics of each college. Naturally, MCC also includes cybersecurity items. However, due to changes in the social situation, it is considered that the current MCC lacks the cybersecurity skills required to be active as engineers. Therefore, K-SEC is preparing a draft in the cyber security field for the next MCC. In preparing the draft, K-SEC leaders extracted items with reference to the standard curriculum in the cyber security field. The extracted items were requested to be mapped by an external security expert and evaluated for validity. In the evaluation, we evaluated whether graduates of colleges cover the required cybersecurity skills for various occupations expected to be employed in the future. As a result, it was found that it covered the skills required for graduates in fields other than information systems. Based on this mapping, we have drafted the next MCC, which has significantly more cybersecurity skills than the current MCC.

Model Core Curriculum

In 2012, KOSEN formulated MCC as a learning goal to be reached by all students in order to guarantee the quality of education. MCC classifies the contents to be learned into basic skills that engineers must have in common, specialized skills in each field that engineers should have in common, and cross-sectoral skills that engineers should have in common. MCC shows the skills that engineers educated in KOSEN should have based on their career paths. The original MCC was revised in 2017. KOSEN education is being promoted in accordance with the revised MCC.

The current MCC includes information security items in the basic engineering category as basic capabilities. The contents specified in the information security section are as follows:

+Awareness of the necessity for information security and the information to be protected.
+Basic consideration on personal information and the concept of privacy protection.
+Recognition of various threats on the Internet (including SNS) and computer usage.
+Explanation about countermeasures to be implemented against various threats on the Internet (including SNS) and computer usage.

Due to changes in the social situation, engineers have become required to have a wider range of information security skills. Therefore, we are now working on drafting next MCC that includes information security technology items that should be acquired by engineers in all fields.

Examination using existing curriculum standards

In drafting the next MCC, we will refer to the curriculum standard in the cyber security field. As a curriculum standard, we referred to i Competency Dictionary (iCD) created by Information-technology Promotion Agency, Japan (IPA) (Information-technology Promotion Agency, Japan (2016)).

iCD is a systematization of the tasks required of a business that utilizes IT in a company, and the abilities and skills of IT human resources that support it and was released in 2015. iCD refers to various international knowledge systems (CISSP, IEEE SWEBOK, etc.), and is also related to the Information Technology Engineer Examination of the Japanese Ministry of Economy, Trade and Industry. iCD is composed of thousands of items related to the life cycle of information systems and roles related to information systems.

It is necessary to evaluate the validity of these extracted items to determine whether they are suitable for engineering education. Therefore, we asked Japan Network Security Association (JNSA) security expert to evaluate the validity. JNSA has released SecBoK, which organizes information security knowledge items from the perspective of skills, tasks, and roles (Japan Network Security Association (2019)). SecBoK maps 16 roles that are assumed to be involved in cyber security and the skill items of NIST SP800-181 (National Institute of Standards and Technology (2017)). 16 roles include occupations where cybersecurity professionals will be employed, such as forensic engineers and researchers, and senior executives, such as CISO. n preparing the draft for the next MCC, we focused on Point of Contact (PoC) and notification. PoC serves as a point of contact with external regulatory agencies, security vendors, CIRTs, etc., and is responsible for information sharing. The PoC also provides information sharing with the IT department, legal affairs, and public relations for the company. PoC needs not only basic IT literacy, but also communication ability to convey information correctly and ability to judge information appropriately. Notification is the role of coordinating within the organization and transmitting information to relevant departments including the IT department. The abilities required for notification are like the abilities required for PoC, but also require knowledge of the organization's system and negotiating abilities. Knowledge of incident response and handling is also required for notification. These roles are likely to be graduates of non-information fields with cybersecurity skills.

In the mapping between the items extracted by the K-SEC leader and SecBoK, it was evaluated that the relevance was high for the ability required for PoC and notification. Therefore, it can be said that cyber security skills that graduates in fields other than information systems should have are widely covered. Based on the results of this mapping, we will prepare a draft of the next MCC, listing the cybersecurity skills to be acquired in all areas.

Draft of next MCC

Based on the mapping results, we have sorted out the cybersecurity skills required for graduates in all areas. As a result, draft of the next MCC that is substantially more enhanced than the current MCC has been created. The drafts are roughly divided into eight categories as follows.

1. Moral and literacy
+ Investigation for the truth of information based on evidence
+ Understanding the effects and responsibilities of releasing information, and take moral and ethical considerations

2. Basics of computer
+ Explanation of the basics of ports and services in operating systems
+ Explanation of the role of operating systems
+ Performance about basic operations such as information collection and material creation using PC

3. Network
+ Explanation of the outline of the network
+ Explanation of the basic network configuration
+ Explanation of Open Systems Interconnection (OSI) reference model
+ Configuration of general network devices

4. Basics of information security
+ Explanation of the necessity of information security
+ Explanation of countermeasures of information security
+ Understanding that information technology is evolving rapidly, and it is necessary to constantly collect the latest information

5. Elements of information security
+ Explanation of confidentiality, integrity, and availability
+ Explanation of information access restrictions and password authentication

6. Cyber attack and defence
+ Explanation of major attack methods
+ Explanation of how to defend against attacks (prevention and response)

7. Laws, rules, and policies
+ Understanding and compliant with public rules (laws, guidelines, etc.) related to information security
+ Understanding and implementation about security policies and rules in their organization
+ Understanding the rating of the information to be handled (confidential information, public information, etc.) and be able to handle it appropriately

8. Risk management and security management
+ Identification and evaluation of the risk in handling information
+ Suggestion of actions to be taken in the event of security incident
+ Identification for threats (intentional threats and accidental threats) and explanation of risks and countermeasures

In addition to this, we do not include it in the item of cybersecurity, but we consider that the following contents will be reflected in the section of generic skills and information education.

+ Ability to create technical documentation
+ Ability to think critically
+ Ability to understand purpose and effect
+ Ability to communicate complex information, concepts or ideas to others
+ Ability to communicate with others to communicate information efficiently
+ Ability to write difficult content according to the reader

Conclusions

We have drafted the next MCC at KOSEN to enhance cybersecurity education for students in all fields. In the current MCC, utilization of IT equipment and programming are required skills for students. In the next draft of the MCC, cyber security skills which are roughly classified into eight categories are listed. By acquiring the skills, graduates are expected to be active as engineers with cybersecurity skills.

Based on this draft, KOSEN will create cyber security items in the next MCC. Syllabuses are created at each college along with the next MCC, and teaching materials are created accordingly. At all KOSEN colleges, cyber security education will be enhanced for students in all fields.

We will also prepare a draft of the next MCC for students majoring in the information field. In the current MCC, it has been specified that in the information science field, skills related to information theory, hardware, software, and networks are already acquired. In the future, in order to be active as an information engineer who is well versed in cyber security, knowledge of cyber security associated with these technologies and knowledge of the legal system will be required.

When considering the next MCC in the field of information science, we would like to refer to the curriculum standard of the Information Processing Society of Japan. Information Processing Society of Japan formulated and published curriculum standard J17 in 2007 (The Information Processing Society of Japan (2017)). Based on CC2001-CC2005 of the US ACM / IEEE-CS (The Joint Task Force for Computing Curricula 2005 (2005)), which is a global standard, it has been revised in accordance with the situation of information education in Japan. In 2017, the curriculum standard J17 was completely revised, with the addition of an information security category.

As with drafting the next MCC for students in all fields, it is necessary to consider what roles graduates will play in society. The following roles can be considered as roles that can become cybersecurity experts: Researchers who collect security events, threat information, vulnerability information, etc., curators who analyse the information collected by the researchers and select whether to apply the information to their own organizations, forensic engineers who perform system forensics, etc. As an information engineer with knowledge of cyber security, it is possible to belong to the IT system department and play the following roles: Administrator of information systems, security auditor who diagnoses vulnerabilities in information systems and advises on improvements, and commander who performs overall control of security incidents occurring in own organization and cooperates with management. In addition, the role of an educator may be considered to improve cyber security literacy for non-information related staff.

Since the roles that students majoring in the information field can take are wide, when planning the next draft of the MCC in the information field, we will consider which field to focus on in the future.

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A PRACTICE OF SCIENCE COMMUNICATION THROUGH DRAMA PRODUCTION

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Abstract

To handle socio-technological subjects, students mejoring engineering are required to learn the background actively themselves. Producing drama for communication education has been established as a method to enhance communication ability generally and even for graduate students in Japan. This is a report of an application of this method for the students of engineering in Kosen. The purpose is not just to enhance the communication ability but develop the students' attitude to learn socio-technological problems actively themselves. Drama production is appropriate because it is a media to show the complexity of a society and diversity of values to both performers and audience.

Keywords: *active learning, drama, socio-technological subjects*

Introduction

Nowadays students of engineering must face socio-technological subjects as conflicts among consumers or users and engineers or scientists, for example, what is the most appropriate way to use self-driving cars, where is the best place to set a certain wind-power generation, or, how far we can use the technology of genetic recombination.

To handle these more and more complicating subjects, it is better that the students themselves learn to know actively the actual problems past and present, and research different needs and wants of every party concerned, rather than taking notes while they are given lectures. Moreover, it is much more effective that the students themselves write and perform the situation as a short drama or a skit. In order to make a drama, or to recreate a scene of the conflicts, they must know every sides of the case. To give it reality, they should know not only the words of speech but also the philosophy behind each word.

Sometimes, socio-technological oppositions reflect the difference between the both sides' approach to the same goal. Other times, however, it seems that the gap between two ideologies is so large that it is impossible to discuss the matter effectively. Yet, through making a drama, the participants come to recognize the roles' experiences more positively, and become able to think more diversely than when they learn the subjects just on paper.

In the class called Expressions for the second year of advanced course in National Institute of Technology, Hachinohe College (Hechinohe Kosen), students are supposed to practice some methods of communication of the socio-technological situation including this type of drama production. They do the work in their mother tongue Japanese. The aim of this class is not just to enhance their communication skills but also to deepen their understanding the complicacy of psychology which they would face in the future at their work sites. Besides, through this work, they experience in-group cooperation and acquire some self-confidence, which Japanese students sometimes to be boosted.

Drama as a Method of Teaching Communication

There have been uncountable practices for students of a wide range of age to create dramas, through which they experience various fazes of communication. Drama in education is a basic pedagogy all over the world. Unfortunately, however, there is an exception: Japan.

Even though we have a long history of performing arts and text books of Japanese literature which would teach children the essence, still, most of the students have little practice of such significant part of media, especially during their secondary educational period. Except some extra-class activities, such as drama clubs in some middle schools and high schools, few schools have in-class activities of performing dramas. This is supposedly because the priority of many schools in Japan is leading the students to next step of education; passing the entrance examinations. The other reason of the small number of drama classes is that the shortage of teachers and resources for such kind of method. This state of underestimate is continued into the stage of higher education. Universities in Japan rarely have any programme for performing arts prepared for layer students (Hirata, 2010).

Colleges of National Institute of Technology (Kosen, as they are known) have a similar situation. There have been few reports of classes using drama as a method of teaching communication. It is no surprise because even a Kosen shares the same educational system in Japan, and we have very small population who have been systematically trained for teaching drama, especially not at the special course of performing arts but in regular or engineering schools.

Yet, around 2010 or after, we have seen a few practice of teaching communication as general education for graduate students. Osaka University started a Drama Workshop in 2008 and Drama Creation Seminar led by a professor and dramatist, Hirata, Oriza, who calls this attempt as a forerunner in this field in Japan. He explains the aim of the courses that the students will acquire the global communication skill which OECD regards as fundamental ability for present students (Hirata, 2010).

According to the syllabus, in the four months class, Drama Creation Seminar, there were students from all departments of the university. The programme was for the 5th and 6th-year students, meaning students from the last two years of six-year course of medical education and students from the first two years of graduate schools from other fields, such as master course for engineering, sciences, or, law school.

The students were divided into groups of 5-7 which included students from different departments. They were supposed to write and perform a short drama of 15-25 minutes at the end of the class. The themes were to have some relationship to their major, but, as the members' ones were various, several students were lay persons for the subject. The point of this condition is that the group is a pseudo society, where diverse people should encounter and discuss anything if it is required.

It is reported that about 90% students who attended the class reported that they were very satisfied with the class.

Science Communication and Drama

Originally, the term science communication was used to describe the process for scientists to communicate or inform knowledge about a certain scientific subjects towards the public. In 1991 there appeared a criticism against the one-sidedness of this kind of communication. This type of communication is now known as a deficit model. In a deficit model, it is regarded that whole the knowledge about a subject is pooled in the specialists' community and its information is flowing to the non-specialists' community. After the criticism, another type of communication has been proposed; the contextual model. In this model, non-specialists are thought to play more positive parts. They try to gain information they need on their own interest. The discussion on the science communication models has been continued and the importance of the role of non-specialists is estimated much larger. Anyway, it seems that the responsibility of science communicators is still significant offering proper information on the appropriate occasion (Fugigaki and Hirono, 2008).

Basically, science communication is carried by specialists, such as scientists and engineers themselves, so that there seem to have been few practice of science communication through performing a drama. However, this is not so reasonable if you remember the practice of role playing as training in the medical field or performing case studies by lowers to attract citizens' attention.

Recently, a course for graduate students aiming to be a professional science communicator, such as a science journalist or a curator at science museum, employs the method of producing a drama. Communication in Science & Technology Education & Research Program (CoSTEP) in Hokkaido University has developed an approach of science communication through drama since 2015.

The Purpose of the Class in Hachinohe Kosen

The class called "Expressions" is held for the second-year students of Advanced Courses in Hachinohe Kosen. The Purpose of the class is to enhance students' abilities for communication skills as would-be engineers, through reading, writing, and discussion. One of the points of class setting is that there are all the students of the grade from every part of their majors because this is a compulsory class. Therefore, inevitably not all the students will be the specialists of a topic at the same time. Usually, the theme of their discussion is a certain socio-technological subject, so that none of them feel that the theme is their so-called speciality of their own research of engineering.

At every class, students are divided into groups of 3-4, among whom they share the same topic of the day, reading and making some discussion. The purpose of the discussion is not to find a conclusion. They do not have to agree each other. This class is an arena to face the reality that there are various ideas about a certain same subject; to endure the solitude when you cannot share your value; and, still to admit others' right to have their own opinions. In short, students are expected to become flexible to diverse circumstances.

The other significant aim of the class is to prepare chances for students to see engineering in a context of socio-technological way. As would be engineers, they should know that there are many matters and problems which are not answered by only scientists and engineers. Every section of a particular case of conflict or debate about technology has its own ideas and values. They have their own reasons and to know them is the first step of solution.

Background of the Students

Recently, Hachinohe Kosen's advanced courses have not accepted students other than its five-year courses for years. Therefore the students about whose class this article introduces all had graduated from Hachinohe Kosen about one year before. This fact means that all the students had had the same liberal-arts education for six years before the class. As for preparatory, they experienced a class called "communication" when they were third year and fourth year students, and science and technology studies during their fourth year.

The number of class member is around 30, depending on their entrance year. As stated before, the members are from Industrial Systems Engineering Advanced Department (Advanced Course) which consists of Mechanical System Design Course, Electrical & Computer Engineering Course, Material & Biological Engineering Course, and Civil Engineering & Architectural Design Course. About a half of them are to enter graduate schools and continue to be students at least two more years. Usually, as the entrance examinations to the graduate schools are held in July and August, this class is a kind of preparation for them to write articles sometimes they are required for the exams.

Because all of them have stayed at the same campus for more than six years, some are acquainted with each other very well, but, on the other hand, some know others just by sight and names. They say that most of them do not discuss any serious subjects on their own.

Background of the Teacher

This class started about twenty years ago, since the Advanced Course established in 2002. The style of the method has depended on those in charge. I took the responsibility in 2018.

Before that, I have taught mostly English, for about ten years for several other colleges, then more than fifteen years at Hachinohe Kosen. The English classes included those which taught English for Science, using a textbook of physics written for GCSE candidates in Britain. Then, I also started teaching classes named "Communication" for Japanese students through their first language; actually, "Communication I" for the third-year students and "Communication II" for the fourth-year students. The latter one is a lecture of communication theories and the first one is for reading and writing Japanese, that is, usually called "Japanese Language" classes in Japan. The target of these classes is to introduce the basic theories for communication and to instruct how to read and write analytically.

As for drama, I have some experiences as a teacher in charge of the Drama Club of Hachinohe Kosen for more than fifteen years. Kosen's first three years correspond to those of high schools in Japan. So, many clubs in Kosen participate in the leagues for the clubs of high schools. Most leagues have a contest or meeting every year, which many students regard as an aim of their extra-class activities. Drama clubs also hold a series of contests, which leads to a national meeting. All the participants perform one-hour stage, which are often newly written by the students and teachers. Hachinohe Kosen's drama club makes it a policy that the play should be written by one of the students. The teacher is just an adviser to help them to accomplish their work.

Through this experience, I have found that the steps of writing and performing a stage is a sort of active learning. As a number of former studies and reports have declared, performing a play requires the actors a whole vision of the roles they represent. The reality on stage is indispensably built on the reality the performers acquire, which is not gained only through imagination, but also by accessing facts and data. Therefore, every good actor often reads books and watches pictures to explore the background of any single line.

When you write a drama, even a line requires the writer to have a view about the scene. Yet, writers usually do not have the complete scheme beforehand. Writing a drama is a process to develop itself through writing. To fuel the work, a writer needs to read about their subject and discuss it with others. This is undoubtedly a practice of active learning.

Back to our college's drama club, there is a trend or a tradition for them when choosing a subject. Sometimes it turns to be a kind of "scientific" one, maybe because it reflects the students' everyday interests. One of the most successful drama depicted an accident at a nuclear power plant ten years after the Fukushima 1's. To finish the play, the writer/student read a lot of resources and asked questions to a physics lecturer (at that time). The stage won the two steps of the contests to become a contestant of Tohoku Regional Meeting in 2011.

Before this remarkable work, there had been a stage about a laboratory set in a near future with warmer climate. It was a black comedy with an eccentric scientist, who invented a method to change animals into plants through gene manipulation in order to stop the climate change and save the planet. Surely the story is absurd, but it comes from the students concern about the subject. The writer built this fiction on a basis of the contemporary knowledge he got through research.

Recently, we had another stage with an android as a high school student. The writer, who was a second-year student of mechanical engineering at that time, had a sense of crises about the future of artificial intelligence. This work also reflects her concern in a socio-technological way.

As a result, I have ensured that through writing a drama, students would learn actively about their subject easily. Moreover, when they perform, they should imagine the others' circumstances, so that drama is a better tool for students to experience a matter in conflict, than a report, which is tend to be written one-sidedly. The study of these experiences are published as "Drama production as a practice of active learning" (Todayama, 2017) and "Do You Need Any Qualification to Write? : Authenticity and Imagination for SHINSAI Theater Arts in High Schools" (Todayama, 2019).

Steps and Activities in the Class

However, when I started the class "Expressions" in 2018, I had no idea to design the syllabus with a process of produsing a drama. Since the first year for my responsibility, I have utilized a textbook titled *Kagakugijutsu wo Yoku Kangaeru (Thinking Critically on Science, Technology and Society)*, which is declared to be written rather for graduate students in scientific or engineering courses. The book consists of ten units with each subject, which has two discussions from both sides, with explanations of the background. Readers can learn that there are several points of view at every conflicting matter. The subjects are following (English translation is mine).

Unit 1 Genetically Modified Crops.
Unit 2 Practical Use of Results of Neuroscience.
Unit 3 Is Smoking Acceptable, or Not?
Unit 4 Is a Checkup for Brest Cancer Recommendable, or Not?
Unit 5 Can you Tell a Personality on the Basis of the Blood Type?
Unit 6 How to React Global-Warming Hypotheses.
Unit 7 Investment in Space Science and Exploration.
Unit 8 Prediction of an Earthquake.
Unit 9 Pro or Anti for Animal Experimentation.
Unit 10 The Reason for Discussion of the Use of Nuclear Bomb.

To enable the readers to understand the points of discussion, the textbook provides a set of ideas from science communication and science philosophy, such as “precautionary principle”, “paternalism”, “double blind trial”, “risk communication”, “public engagement”, and so on.

In classroom, attendants are divided into groups of 3-4, and to discuss sometimes as the discussions in the textbook, or sometimes on another similar topic given by the teacher. Occasionally, they are told to find other topics which are applicable to the subject, such as paternalism.

The purpose of the discussion is not to settle a conclusion, but to tolerate other people’s ideas. So, the students are encouraged to speak out what they feel frankly. There is no “right answer” to most of the discussion about science and technology because the practice of application depends on the circumstances and they would change. So, the search for better idea needs the attitude flexible enough to accept the difference of values.

In 2018, each group presented a plan of science café according to their interests as the final assignment. They prepared well and it was enjoyable to see that the students tried to explain what they had researched. Yet, it was rather difficult for other students to become involved. There were few questions and fewer discussions. It seems that asking a question at the site of presentation is rather difficult because it requires some background knowledge.

After the semester, I decided for next year to employ drama as the final presentation, which means choosing a theme, writing a script, and performing a stage.

In 2019, 70% of the lessons were the same as those in 2018. Students had discussions in a small group. The syllabus had two more activities besides the change at the final assignment.

First, as I had found a sad fact that most students did not read newspaper, or, even news sites periodically, I prepared the number of copies of newspaper for each student. They read their own copy in class and shared what they read to discuss in groups. They had to seek any relationship between science / technology and society in these articles. Each group gave a presentation on what they found after the discussion. This is a type of activity promoted among elementary schools, yet, I found it works even for college students.

Another activity was a kind of solo-presentation on a book they had read, called “Bibliobattle”. According to its official site, “Bibliobattle is a social book review game which was developed in the Graduate School of Informatics at Kyoto University in Japan”. A presenter, called “bibliobattler”, brings their favorite book and talk about the book to the audience for five minutes. After all presentations, the audience, including the presenters (who can vote just for other battlers’ book), decide what is the best book of the day. This type of event is now employed at libraries, booksellers, schools and even online in Japan. I had taken this activity for another class of “Communication” before. Usually, because of the limit of length of a lesson and the difficulty for many students to talk so long, I use shorter version with three-minutes rule.

Through these activities, the students reflected their interests on the theme of the class, that is, the relation between science / technology and society. At the eighth lesson, just at the half of the class, the students shared their own “theme” with other students to find out those who had similar ideas. They made a “team” for the final presentation and started to prepare it as extra-class works.

Final Performances

The purpose of the final performance was to have a chance to treat a techno-sociological theme as participants’ own involvement. One of the most important part is that they have some sense of diversity about the subject they choose and to communicate its various aspects to the audience. They had to write a short dialogue among three people on a subject, during which a certain kind of conflict or argument should be shown. Those were to be at most eight minutes because of the limitation of ninety minutes’ lesson. The skit was so short, and so intended, that they were supposed not to arrive to a conclusion. The dialogue would be cut in the middle of dispute, leaving the audience at a loss. This kind of ending is usually called “open ending”.

Students were also required to create a round character as a role to give some reality to their scene. They were told to imagine the character’s background, such as his or her job, state, family, and most importantly, values. Many of them referred to their own experience, and, most of them did research.

Because it aimed that the performance should be a drama, they were encouraged not to use handouts or PowerPoint, which usually are utilized when they give a presentation. But they were allowed to have their lines at hand because it was not a purpose to play a role like an actor. Actually, most of them were very well prepared and performed without notes.

The subjects they chose were as follows.

Team 1: A dialogue on the right or wrong of using agricultural chemicals.
Team 2: A meeting of people who keep endangered species.
Team 3: Is a self-driving car acceptable, or not?
Team 4: Thirsty? Then, drink "hydrogen water."
Team 5: The right or wrong of a fast breeder reactor.
Team 6: Which to buy, electric vehicle, or gasoline vehicle?
Team 7: A father's concern (on cloning for a spare).
Team 8: Ethical problems of animal experiences.
Team 9: A scene from an explanatory meeting by the government on legislation of micro-tips for domestic animals at home.

As is shown, they tackled several controversies of this modern society especially from the point of technology as they were expected. For example, Team 6 presented a trend concern. That is a scene at a car dealer, where a young man comes to buy a new car. His friend, who loves to drive a fast car, wants to recommend a gasoline vehicle. On the other hand, the dealer explains the changes of circumstances, such as the increase of the number of electric vehicle charging stands, or the technological shift ongoing abroad. Actually, he also loves a traditional automobile, yet as a professional, he provides the newest information to the consumer. The young man starts to think again which model to buy.

The performances were evaluated not only by the instructor but also the students themselves, according to the rule of Bibliobattle. There was a guest audience, their mathematics class' teacher, who participated in the evaluation.

Results and Discussion

According to the students' comments, they enjoyed the final performance very well. They appreciated others' works, especially the subjects they choose. This activity seemed to enhance the students' view of the socio-technological relation. It was regarded that the syllabus needed little change.

Unfortunately, in 2020, the first five lessons during April and May were held online because of avoiding closeness as the campus policy against the COVID-19 pandemic. But the contents were almost the same as the former year; just they discussed online, such as e-mail exchange and using a remote conference system. After every lesson, students reported their reflection on their own participation. It is interesting that some students found that they felt less nervous at online sessions. Most students said that sharing written materials together took more time than a discussion, yet, writing itself was better for clear thinking.

There is to be small changes on the steps. First, because of the online condition, the activity on news articles used only online articles. The students shared what they read among a small group and discussed the subjects. The Bibliobattle, which is going to be held in June, will have clearer theme, the relation between science / technology and society.

Conclusion

This class "Expressions" is designed for the students of the second year of advanced course of Kosen, which correspond to those of the last year of a university. Some of them are going to the labor site as engineers in the following year. They would face the reality of society, which sometimes challenges them. Others, who would go ahead into graduate school, should be responsible on their research subjects, which are influenced by society's demands. It is the last chance for them to be prepared for such circumstances.

Using drama for enhancement of communication ability is effective as many former studies have shown. This method is also useful because students learn actively in order to perform well. But it is more recommendable for the students majoring engineering because drama is a media which do not demand an apparent conclusion. This is a small simulation for them, who are to tackle socio-technological conflicts soon.

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TRANSFORMING LEARNING EXPERIENCES: AN LXD APPROACH

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Abstract

Like learning any new skillsets, drawing can appear to be rather intimidating for many new learners, as they may lack confidence in both technical and artistic skills. Many learners reportedly hold the fear of drawing 3-dimensional objects in perspective even as they progress into their final year of studies, hindering their abilities to advance their skills further. How can we help learners transform their fear and resistance in learning perspective drawing into positive learning experiences? This research paper describes how the Learning Experience Design approach is applied to design engaging and effective instructional activities and formative assessments enhanced with accompanying learning aid, *The Perspective Toolkit*.

To better understand the learning experiences of learners and the effectiveness of the instructional design, mixed-method applications in action research was employed. Quantitative research tool like survey questionnaire was used to collect statistical data from 40 Poly-Foundation students, 50 year one students and 10 year three students. Qualitative studies were also carried out for 30 students, 10 from each of the above-mentioned groups, to collect findings through focus group discussion. The research was conducted with these group of learners during regular class timings. The instructional strategy was to split the lesson into bite-size activities and formative assessments to allow lecturers and learners to have co-ownership of teaching and learning through scaffolding, supported by *The Perspective Toolkit*, which was conceived and designed using Learning Experience Design strategies. The goal was to provide learning experiences that address learners' needs and pain points, with a focus on helping them overcome the fear and challenges faced in perspective drawing.

The findings suggest that the creation of significant learning experiences better foster meaningful and memorable learning engagement. Understanding learners' needs and designing instructional activities with supporting foundational tools and materials help facilitate learners to confidently achieve the desired learning outcome with renewed motivations to take on higher-level learning. The learning experience design process has not been extensively studied in the area of perspective drawing, and future studies may include exploring the effectiveness of the aforementioned teaching approach that would, in turn, validate the current study's findings.

Keywords: *learning experience design, instructional design, learner-centered, learner engagement, learning behavior, action research*

Introduction

The pedagogy approaches for the twenty-first century are very different from those of earlier times. For the past decade, educators from higher education are favoring student-centered pedagogy over a teacher-centered method of instruction (Moate & Cox, 2015 cited in Brown, 2003; Crick & McCombs, 2006; Harris & Cullen, 2008, p. 1). Student-centered approached focuses on designing learning experiences that enable active learners with independent problem-solving and lifelong learning skills. Instead of solely focusing on transferring information to students, students' learning experience, and their understanding of the learning materials presented should be considered. This requires the teacher to invest time in understanding the learning of their students by paying close attention to the actual learning process students are undergoing (Blackie, Case, & Jawitz, 2010).

In order to enhance students' learning experience, teacher must design a learning experience that centers around the learning process (Schreurs & Dumbraveanu, 2014) and not merely a teacher and textbook source disseminating information to students from which the student may or may not learn (Lee & Lowe, 2018 cited in Noddings in Goldstein 1999, p. 659). As mentioned in Dewey's (1915) 'Schools of Tomorrow' book, "teacher and book are no longer the only instructors; the hands, the eyes, the ears, in fact, the whole body, become sources of information, while teacher and textbook become the tester and the starter respectively. No book or map is a substitute for personal experience; they cannot take the place of the actual journey" (p. 74).

Students' learning and motivation are tightly knitted to their emotional state. According to Fredrickson (2004), positive emotions, such as joy, interest, excitement, and love to create are the emotions that drive an individual to play, explore, and acquire new experience and information. On a contrary, negative emotions such as fear, anger, sadness, and anxiety could disrupt the open flow of ideas and affect problem-solving

(Akhtar, 2014). This could be witnessed in students' struggle with complex and challenging assignments. The lack of understanding of content could bring about frustration in students (Graesser & D'Mello, 2012). Negative emotions such as boredom and fear can hinder their motivation (Rowe & Fitness, 2018), which can contribute to breaking concentration, shortening attention span, and disengagement (Rowe & Fitness, 2018).

Background

Our student comes from a diverse background, with a majority that has not received basic training on drawing before their enrollment into the School of Interactive and Digital Media (SIDM), in Nanyang Polytechnic. The course is structured for students to begin their year one training with modules focusing on fundamental design, colors, and drawing.

As a drawing tutor for many years, the yearly new cohort of students has been seen struggling with the concepts of perspective drawings. A significant number of students had limited exposure or training in drawing that is necessary for them to be able to complete some of the assessment tasks. As a result, some were unable to demonstrate competency in some of the learning outcomes. Like learning any new skillsets, drawing can appear to be somewhat intimidating for many new students who have no prior knowledge when it comes to the construction of perspective drawing. Many students reportedly continue to hold the fear of drawing three-dimensional objects even as they progress into their final year of studies, hindering their abilities to advance their skills further.

Perspective drawing is a technique used for creating an illusion of three-dimensions objects on a two-dimensional surface. It is a mandatory fundamental skillset required for drawing and anyone in the field of art and design. Drawing tutors are always grappling with identifying the most effective ways to teach our students perspective drawings. Despite numerous resources given to students and live demonstrations conducted by tutors in the classroom, learners continue to make frequent and repetitive errors, otherwise forgetting the concept of perspective drawing. When students are confronted with various obstacles in comprehending the principles of perspective drawing, they will experience a series of confusion, frustration, fear, and other negative emotions. Learning this technical skill leads to a negative experience for students and confounds tutors' expectations. Motivating students have always been a challenge for tutors, and tutors know that emotions undoubtedly play a vital role in linking learning and motivation. As the students progressed to the second-year program, they are faced with more struggles when expected to conceptualize three-dimensional visuals for their assignments. This is apparent when tutors of the second-year and third-year program reportedly need to run through the concept of perspective with them once more. Henceforth, a question to consider would be: How can tutors help students transform their fear and resistance in learning perspective drawing into positive learning experiences?

To address this issue, a team of drawing tutors decided to re-look into the teaching of perspective drawing. Incorporating the idea that learning experience is an important facet of student-centered pedagogy (Moate & Cox, 2015) that can improve the quality of student learning by ensuring the learning journey is lively, fun, relevant, and informative (Rowe & Fitness, 2018). As such, the teachers decided to introduce a new pedagogy using the Learning Experience Design (LXD) approach along with the traditional teacher-centered approach as comparison. The LXD approach will focus on learners' experience that can effectively deal with their need and struggle, on contrary, the traditional approach will focus on the tutor giving lecture and live demonstration in class. Although the traditional approach comprised practical classroom activities that are somewhat student-centred, learning is still predominantly controlled by the teacher. This research aims to explore the effectiveness and engaging instructional strategy using the LXD approach. The main objective is to demonstrate that – through the LXD approach – students can perform certain tasks at the end of the learning period and achieve the desired learning outcome as a result of engaging learning activities.

The stimulated active learning can, as a result, combat their fear and resistance to learning complex content, in this case, the perspective drawing. The teacher's main task and responsibility are to create a learning environment with appropriate instructional activities that can effectively achieved the intended learning outcomes. Teachers take on the role of facilitators and work on improving rapport with learners. Consequently, the relationships between teachers and students evolved as both collaborate and share equal responsibility in learning. To achieve this, openness to unpredictability as well as flexibility towards self-reflection and change are necessary for both instructors and their students. (Moat & Cox, 2015 cited in McAuliffe & Eriksen, 2002, p. 4). According to Moate and Cox (2015), these teachers place learning at the center of the classroom environment, where both teachers and students work towards generating a meaningful learning experience. When students find that the classroom is a safe space, recognizes meaning and purpose in their learning; and learning is motivated by classroom activities, they tend to exert deep and meaningful learning (Moate & Cox, 2015), hence shaping their learning experience can have significant impact on study behavior.

Methods

The research was conducted during regular class timings with a total of 100 participants, consisting 40 Polytechnic Foundation Programme (PFP) students and 50 year one students and 10 year three students. The participants from the Polytechnic Foundation Programme and year one students have no prior knowledge of perspective drawing. The PFP and year one students are learning drawing module; a component of the module requires them to study perspective drawing. Drawing tutors did some ground check with the students through casual conversations found out most of them went through learning mostly focus on a teacher-centered approach during their studies in secondary school. On the other hand, the 10 year three students have been through the learning of perspective drawing in year one but have forgotten its concept and application. This group of students reportedly struggles with perspective drawing as they progress to their second and third year of studies. The teachers from the second and third year have repeatedly gone through the concepts with them. The 10 year three students are intended for testing the effectiveness of the *Perspective Toolkit,* which was conceived and designed using learning experience design strategies to enhance the learners' experience. They have also experienced the learning of perspective drawing using the teacher-centered approach in year one.

A mixed-method application in action research was employed to initiate change based on a desire and determination to create a 'better' human experience (Cronin & Lowes, as cited in Freire, 2005). Niels Floor's Learning Experience Design (LXD) canvas was used to shape the learning experiences by mapping learner's characteristics, learning outcomes, and objectives with appropriate instructional strategies and activities. The canvas was used to map out better experience design for students focusing on their needs and insights about their learning pain point. The canvas helps to give a holistic view of designing good learning experiences from the learners' perspective, and at the same time, keeping track of the realistic constraints when running the lesson.

The instructional strategy plan was to split the lesson into bite-size activities to allow teachers and students to have co-ownership of teaching and learning through the scaffolding of blended learning, experiential learning, formative assessments, and summative assessment as shown in Figure 1.

Figure 1: Instructional Activities

The team brainstorm to find a possible engaging and interactive toolkit solution to help learner visualize the fundamental principles of perspective drawing. The team created a *Perspective Toolkit* that can help students fulfill the learning outcomes through a more interesting and goal-directed way. The goal of *The Perspective Toolkit* is to help learners transform their fear and resistance in learning perspective drawing into positive learning experiences. Below is an illustration of *The Perspective Toolkit.*

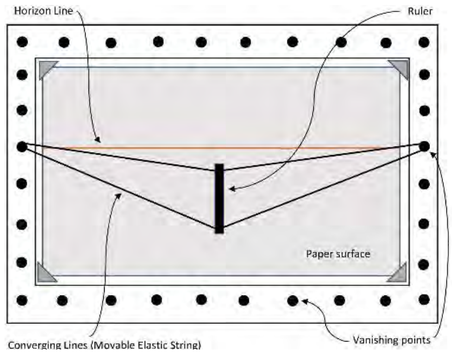

Figure 2: An illustration of The Perspective Toolkit reflected the main principles of perspective drawing to help students visualise vanishing points, converging lines and horizon line.

The traditional way of teaching perspective drawings always required teacher's demonstration and steps by steps guidance in the fundamental knowledge and skills of perspective drawing. *The Perspective Toolkit* aims to introduce a significant change in the way teachers and students approach the learning experience by facilitating independent learning supported by the blended learning approach. The blended learning content was created and uploaded onto a common digital learning platform called Polymall, whereby it is made accessible for all level students to visit or re-visit the material again at their own time and pace. Hence, empowering the students to have control over their pace of learning and to assert ownership to their learning. The formative assessment encompasses a test to ensure students' understanding of a perspective drawing before moving forward. Based on the outcome of the test, teachers can keep track of students' progress as well as identify and help those facing difficulties. Finally, the summative assessment is used to measures student learning and application of perspective drawing with more complex three-dimensional forms as applied to a real-life environment.

The testing was conducted in three different group. The 40 PFP students in Group 1, 50 year one students in Group 2 and the 10 year three students in Group 3. In Group 1 and 2, the learners are separated into group A and B. Group A were put through learning using LXD approach and group B went through learning using the traditional classroom approach simultaneously. This is to allow learners to experience both traditional and LXD approach to make a better comparison of their learning experiences. Since the 10 year three students in Group 3 have been through the learning of perspective drawing in year one using the traditional classroom approach; we just focus on using the LXD approach with them.

In Activity #01, the blended learning content was uploaded online. The blended content consists of one-point and two-point perspective drawing concepts. Students from group A spend the first 30 to 45 minutes of their class time to go through the one-point perspective content on their own. Rather than relying on the teacher delivering class lecture, students were now responsible for their learning. To maintain learners' interest, the online content is broken down into smaller units with lots of visuals and interactivities. Upon reflecting on the content, students were expected to undertake a simple online quiz to test their understanding of the fundamental concepts on one-point perspective drawing, for which they received automated feedback on their answers. After attempting the online questionnaire, the students from group A are further divided into sub-group of 2 students. In the next 30 mins learners will complete the tasks in Activity #02, each sub-group is given a *Perspective Toolkit,* step by step instructional video on how to use the *Perspective Toolkit* was made available online. While one student in the sub-group used the *Perspective Toolkit* to practice one-point perspective drawing on paper, the other student would video record the drawing process using his/her mobile phone, and vice versa. Such peer interaction increases students' opportunities to actively participate in the classroom rather than playing a passive role in learning. Besides, among their peers, students tend to have a more positive attitude towards mistakes and would be more receptive to make corrections.

While students from group A gets to experience the LXD approach, students from group B have only teacher as their primary source of information. Group B students gathered to watch the teacher performing live demonstrate on one-point perspective drawing. After that, students will return to their table to practice one-point perspective drawing on paper without any guiding toolkit. The teacher would provide guidance upon students' request to help clarify doubts and questions. Together both groups A and B take part in Activity #03, formative test to assess their understanding and knowledge in one- point perspective drawing.

When learning two-point perspective, group A and B are flip-flopped so group B were put through learning two-point perspective using the same LXD approach whereas group A learns the two-point perspective using the traditional classroom approach. Once again, both groups A and B were given a formative test to assess their understanding and knowledge in two-point perspective drawing. Lastly, after both groups of students had learned both one and two-point perspectives they are engaged in Activity #04, a summative assessment at the end of the instructional activities to conclude the entire learning process. The students are required to complete an individual assignment based on the theme in which they can relate to the real world, 'The Ban on Single-use Paper/Plastics.' The purpose of the assessment is to measures student learning and application of perspective drawing with more complex three-dimensional forms as applied to a real-life environment. This summative assessment focuses on the learning process from ideation to the finished product, together with feedback sessions conducted to improve students learning outcomes.

Results and Discussion

A quantitative and qualitative approach was used in our study. Quantitative Data was collected from 100 students**,** 40 Poly-Foundation students, 50 year one students and 10 year three students. The statistical data collected are used to measure the effectiveness of the learning experience of the instructional activities with accompanying physical learning tool, *The Perspective Toolkit.* The 10 closed questions in the student questionnaire required learners to rate their level of agreement based on a five-point Likert scale (i.e., strongly agree, agree, neutral, disagree, strongly disagree). Qualitative studies were also carried out for 30 students, 10 from each of the above-mentioned groups using opened-ended questionnaires to gather learners' feedbacks. Strategies for the quantitative data collection is to keep the focus group small. This intimate session helps to facilitate a more in-depth engagement with participants to gain a better understanding of the underlying motivation and opinions that participants have, maximizing the potential for discovery of meaningful insights.

Data collected had shown the way of teaching significantly shaped students' learning experiences and affected their attitudes toward their learning. They exhibited improvements in 3 key areas (1) learning engagement & motivation, (2) memory retention, and (3) meaningful & relevance of the topics taught.

(1) Learning Engagement & Motivation

The instructional activities are designed to be student-centered, curating learning experience that strategically stimulates positive emotional reactions in students. Helping them achieve progressive competence from grasping the concept of perspective drawing to application entice higher levels of motivation. In Figure 3, students' response shows staggering high engagement and involvement in the entire learning experience during the class activities. One year three learner comments, "I enjoy this new way of learning perspective drawing. It is refreshing and giving us a more hands-on involvement and discover for ourselves how learning can be fun. The usual sitting down and listening to instructions given by the lecturer may not be as effective to absorb and understand." Tutors observed a positive change in students' learning attitudes, and learners exhibit behavioral, emotional, and cognitive engagement (Fredricks et al., 2004).

Behavioral engagement: Students exhibit enthusiasm when participating in in-class activities, especially when videoing their peers learning process with *The Perspective Toolkit.* Students are eager to try the toolkit, and the interaction between peers significantly boosts student interest in their learning, and increased attention span with the task on hands.

Emotional engagement: Students exhibit positive affective reactions during the activities. They enjoy the social interaction with their peers, and they find it fun and exciting to capture their successful accomplishments on the video. Respondents said that such social interaction makes learning fun, exciting, and relaxing; the entire learning process allows them to be spontaneous, motivated, and give them a sense of achievement. Other participants response, "I have a lot of fun learning with the perspective toolkit, and the videoing process drives me to want to perform well. Our team ends up doing multiple video recordings before we choose the best one to submit".

Cognitive engagement: Students are able to comprehend the drawing construction of three-dimensional forms with the help of *The Perspective toolkit*. Students exhibit mastering of the skills when they start to guide their peers who may be in doubt during the activities. One participant commented, "Interestingly, I realized I could spot mistakes faster while observing my teammate trying the toolkit during the video recording." Another said, "The toolkit makes the construction of the cube easier to understand when the vanishing points are locked down." Students can take on the learning task with peer support, and the tutor observed a shift in learner's willingness to invest more time and effort to complete the task.

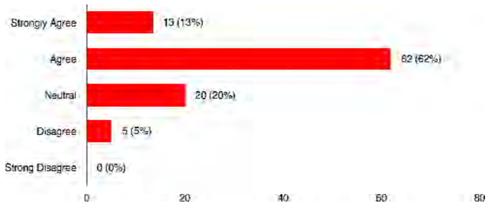

Figure 3: The instruction activities allow you to be spontaneous, motivated, and engage you in meaningful learning

(2) Memory Retention

The instructional activities are broken into 4 key instructional activities (Figure 1), strategically to help them overcomes their challenges and pain points faces in perspective drawing through the scaffolding learning approach. The goal is to help students comprehend the complex theory in perspective drawing through spaced repetition that incorporates increasing intervals as they advanced through the 4 instructional activities. Quiz and test are planted between subsequent review of previously learned material to help them recall key learning points. Student commented that the questionnaire and formative test allow them to reflect, evaluate, and re-enforce their understanding. With the immediate application in the summative assessment, it promotes repetition and recall of knowledge at different stages to enhanced memory retention. In Figure 4, Students' response emphatically to the learning activities that create positive learning experiences that help them to remember what is learned

Figure 4: The learning activities in this class not only help me understand and learn perspective drawing but promote memory retention

(3) Meaningful & Relevance

This scaffolding structure helps students attain the fulfilment of achievement at different stages. When learners break through the common understanding of the subject and can connect what is learned in some way to real-world contexts, it develops meaning and relevance in their learning experiences. Many participants comment that it supports the learning process, and the activities help them to follow through and create continuity from knowledge to application in their final assignment. In Figure 5, students show a positive response to the relevance of the instructional activities. Student comments, "It teaches the fundamentals well. With hands-on practical experiences it allows me to explore variation in perspective drawing useful for my final assignment, making it visually more dynamic." The summative assessment helps students fulfil the learning outcomes through a more exciting and goal- directed way. It empowers students when they see the relevance with the knowledge in the application of perspective drawing with more complex three-dimen- sional forms as applied to a real-life environment.

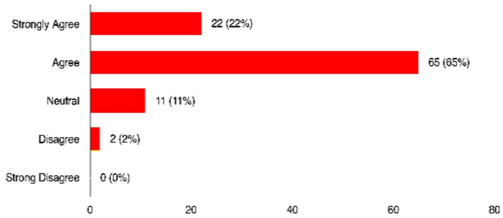

Figure 5: Activities are meaningful and relevant.

Findings

The findings suggest that the creation of significant learning experiences better foster meaningful and memorable learning engagement. Understanding students' needs and designing instructional activities with supporting learning tool and materials help facilitate learners to confidently achieve the desired learning outcome with renewed motivations to take on higher-level learning. The results revealed that learning experiences must be looked at carefully through the lens of students' needs to find an effective way of facilitating the development of competency in students. To avoid learning fatigue, teaching material should be bite-sized and scaffolded into progressive segments. This way, the content becomes more digestible, more natural and intuitive. Designing social interaction into instructional activities encourages peer interdependence, and it has a positive effect on students' effort to achieve, the quality of their interpersonal relationships, and psychological health.

Students liked taking an active role in directing their study at their own pace more than following sequential step by step instructions. Students stated that they were fully satisfied with an educational environment that they could actively engage with and control by themselves. These students had shown a significant change in engagement level when shifting from lecture-type instructions to a more intuitive student-centered learning experience approach. The overall perception from respondents was that the learning experience approach supported with the perspective toolkit provided a beneficial learning experience. Most students also expressed satisfaction with the responsiveness of teaching staff to their learning needs. Teachers reported positive changes in classroom climate and student-teacher relationships.

Conclusions

The LXD approach placed students at the center of the learning rather than a teacher telling what they need to do. It focuses on understanding students' emotions and their intrinsic motivation for learning. Students' learning and motivation are tightly knitted to their emotional state. Learning experiences can be curated to encourage students to be proactive and deliberate students who can teach themselves or seek out teaching from others when and where they need it. A principal aim guiding this study was to understand how students motivation, confidence, and engagement relate to their learning experience.

Students experience a variety of emotions when tasked to develop an understanding of difficult content or problems to solve (Graesser & D'Mello, 2012). Those with low motivation and little interest in learning are likely to experience more negative than positive emotions (Graesser & D'Mello, 2012). Considering that emotions both reflect and influence learning (Grasser & DeMello, 2012) and learners' motivation predicts academic achievement (Ning & Downing, 2010), it is crucial to understand the emotional dynamics that accompany complex learning (Grasser & D'Mello, 2012). As mentioned in Blackie, Case, and Jawitz (2010), Ramsden (1992) suggested that good teaching comprises the components of both an interest in and empathy for students and student learning (p. 638). Therefore, to enhance students' learning, students' need and pain points ought to be assessed before lesson planning and design, with a focus on helping them overcome the fear and challenges faced in learning.

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PROJECT-BASED LEARNING FOR AEROSPACE ENGINEERING EDUCATION

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Abstract

In 2014, the School of Engineering (SEG) at Nanyang Polytechnic (NYP) embarked on a 4-year project-based learning (PjBL) journey for Diploma in Aerospace and Aeronautical Technology (DAAT) students. The theme of the project was to build a full-size 2-seater functional airplane. This project benefitted the students, where besides acquiring practical hands-on skills, they also honed generic skills such as tenacity to overcome challenges, ability to collaborate in a team and opportunities to communicate with original equipment manufacturers.

Building an airplane was chosen as the theme as it is directly relevant and applicable for DAAT students. Prior to the project, domain knowledge such as aircraft structures, flight controls, powerplant, electrical systems, and instrumentation was taught in their first and second years of study. In this final year PjBL, students get to apply their knowledge.

Over the span of 4 years, 34 final-year students participated directly in the building of the structures, powerplant and systems. Every stage of the project was different and posed a unique learning curve for every student. Students were given an assessment rubric that articulated the expectations of their assignment. At the end of their assignment, feedback was collected from selected students as a qualitative measure to evaluate the learning outcomes of the PjBL method. In addition to building the airplane structures, powerplant and systems, several students used the blueprints and airplane components to develop 3D computer-aided design and the development of augmented reality contents.

This paper describes the design of the PjBL, and the challenges faced by the students during the building process. It also provides insights on the motivation and confidence that the projects had brought to the students. All the students who participated in the project had their passion in aerospace engineering deepened. Upon graduation, several went on to pursue a meaningful career in aviation, while others went on to study in prestigious universities in aerospace-related degree programs.

The PjBL has offered a high degree of challenge for all involved and is aligned with NYP's strategic goals of cultivating Innovative and Enterprising attributes as well as a Can-Do spirit in our students and staff.

Keywords: *Project-Based Learning, Applied Learning, Final Year Project, Building Airplane, Aerospace.*

Introduction

Project-based learning (PjBL) is a well-recognized pedagogical approach that is known to strongly motivate students and enhance student learning. It is a dynamic learning approach which advocates for more student centered and experiential approaches to education through active exploration of real-world problems and challenges (Pellegrino and Hilton, 2012).

One of the diploma courses conducted by the School of Engineering (SEG) at Nanyang Polytechnic (NYP) is the Diploma in Aerospace and Aeronautical Technology (DAAT). To enable the final year students to put into practice the knowledge and skills that they have acquired from the course, DAAT has adopted Project-based learning (PjBL) to give students the opportunity to develop knowledge and skills through engaging projects set around challenges and problems that they may face in the real world (Schuetz, n.d.).

PjBL design principles emphasize the importance of the project as the central vehicle of instruction and the students as active participants in the construction of knowledge. The project should foster the application of knowledge and competencies gained in the earlier years of studies in an integrated manner towards addressing an issue of interest (Ho, M. W., & Brooke, M., 2017).

It is a common and widely accepted practice for an Institute of Higher Learning (IHL) in Singapore to purchase an airplane for aerospace-related educational purposes. However, in the year 2014, DAAT took an unprecedented and novel approach to take on the challenge of building a full-size 2-seater functional airplane from scratch. DAAT has been successful in implementing many small-scale aerospace-related projects, but building an actual airplane is by far the most enterprising challenge. 34 students, from different cohorts, took part in this project which took 4 years to complete. This paper will discuss how PjBL approach was employed in the selection, design, and implementation of the project, what are some of the challenges faced in its implementation and the positive outcomes that resulted from it.

Project Theme and Relevance

The application and hands-on components of PjBL are especially crucial in engineering. Therefore, building an airplane was chosen as the theme of this PjBL as it is directly relevant to DAAT students and provides a good platform for the application of their knowledge. Prior to the project, domain knowledge such as aircraft structures, flight controls, powerplant, electrical systems, and instrumentation were taught in their first and second years of study. It is common and acceptable to use airplane models, simulators or small cutaway aerospace components to enhance lesson delivery. However, not many students have the opportunity to get any hands-on work on actual airplane structures and systems. DAAT sought to enhance existing instruction by empowering students with the responsibility of building a plane and providing them with the opportunity to apply their domain knowledge during their final year project (Warren, A., 2016, p13).

Project Learning Outcomes

To design meaningful and specific learning outcomes for the PjBL, the airplane building was divided into the physical development "Fabrication & Assembly" and the virtual design "Digitization". With these categorisations, the learning outcomes were crafted to align them with DAAT's course objectives.

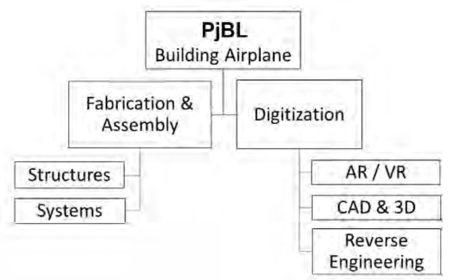

Figure 1: Project Categories

From these 2 main categories, the project tutor developed the desired learning outcomes (LO) that determined the depth and scope of the PjBL. The LO served as a guide in the selection of the airplane model, resources necessary to perform the tasks as well as prerequisites or initial training required to prepare students before they commence work on the project.

Under "Fabrication & Assembly" category, students who worked on the airplane should be able to:

- Observe safety precautions and know the proper usage of personal protective equipment.
- Interpret drawings and comprehend instructional procedures from manuals.
- Be familiar with aerospace related documentation.
- Select the appropriate hand tools to perform tasks.
- Improve their problem-solving skills and be effective in troubleshooting faults.
- Perform work that is acceptable to industry standards.
- Develop an understanding of professional and ethical responsibility.

Students under the "Digitization" category should be able to use the airplane parts to:

- Develop Augmented Reality (AR) training contents.
- Develop 3D Computer Aided Design for parts of the airplane.
- Perform reverse engineering for various components of the airplane.

Project Depth and Scope

Having selected "Building Airplane" as the theme for the PjBL and having prepared the LO, the next step was to decide on the type and model of the airplane that would be most suitable for DAAT students. The selection criteria were based on the LO expected, the ability of DAAT students and NYP's resources.

This initial stage of selecting a suitable kit airplane was crucial to the successful completion of the PjBL. Finding the kit airplane that was appropriate for the students represented a complex task (Heintz, C., 1986). From airplane builders' web pages and blog anecdotal discussions, it seemed to indicate that airplane kit completion ratio is low as many hobbyists who started the airplane building project never finished it.

Project Selection

There were different airplane designs and constructions to consider. Some airplanes made extensive use of fiberglass composites that might cause allergic reactions to students and had to meet strict national health and environment regulations. Other designs used sheet metal, similar to that used in commercial airplanes requiring thousands of rivets to be driven on the structure, which would be ideal for learning. Some designs required the use of fabric and wood, a romantic reminiscent of yesteryear, which needed skills that are now obsolete. (Heintz, C., 1985).

DAAT's final decision was to select an airplane kit that is approved by the Federal Aviation Administration (FAA). The model chosen was the CH750, a two-seater aircraft designed by Chris Heintz and produced by Zenith Aircraft Company, featuring fixed leading-edge slats for high lift, full-span flaperons, an all-flying rudder, and a durable all-metal construction.

The Zenith CH750 kit was selected based on two main reasons:

- Proven design: The kit is approved by FAA (FAA, 2018) and the design was based on an earlier successful model that was first introduced more than 25 years ago. This criterion was a key factor for the selection.
- Complete kit: The kit had been developed to provide the builder with everything needed to complete the airframe with only basic tools and skills, making it ideal for students to focus on the project without having to grapple with specialized tooling. It would have been unfortunate if the project had to be aborted

due to unexpected complexity or the lack of specialized tooling.

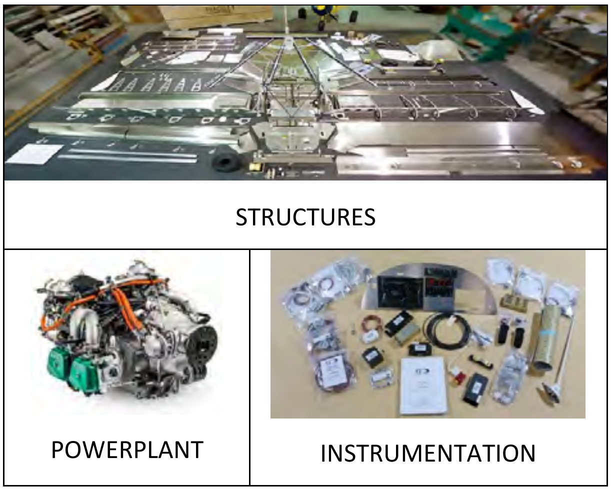

Figure 2: Airplane Kit
(Source: Zenith, with permission)

Project Stakeholders

There were two main stakeholders in this PjBL, the students and the project tutor, each with distinct roles.
In the building of the plane, students had to take ownership of their assigned tasks and not be too dependent on the tutor to solve problems for them (Ho, M. W., & Brooke, M. 2017). Although it is normal for DAAT to assign one student for each final year project, this airplane building PjBL was a team effort by 2 students, with defined tasks assigned to each student for assessment purposes.
The tutor's responsibilities were to ensure that the assigned tasks are appropriate for the level of studies of the students and could be completed within 12 weeks. In addition, the tutor had to provide adequate and appropriate intervention to ensure that the project progressed in accordance to plan. In some PjBL projects, it might be optional for the tutor to be a subject matter expert. However, in this airplane building project, the tutor had to have sufficient knowledge and skills to fulfill his role and responsibilities.

Student profile and Project Assessment

All the students working on this project were from DAAT doing their final year of study. They were allocated 12 weeks each to complete their assignments. The project tutor made conscientious effort to pair up students with complementary skill sets to support each other.

All the students were assessed on their learning through a variety of assessment modes. Besides having to complete the assigned tasks successfully, each student was required to make two oral presentations to three independent assessors, one in week 6, and the second in week 12. There was also a report that each student had to submit at the end of the project that covered an overview, project deliverables, tasks completed, and the challenges encountered.

Challenges

One of the key features of the PjBL approach was learning through experiential approaches and through active exploration of real-world challenges. The airplane building project allowed many opportunities for students to plan, build, trouble-shoot and to find creative ways to solve problems encountered.

Mistakes as a source of learning

Although the students were inexperienced, they were all eager and keen to participate in the PjBL. Hence, the tutor for the project had to be very vigilant in guiding the students and to make constant assessments of their abilities and motivations during the project to equip them with the appropriate skills so that they can take on the challenging tasks assigned to them.

Initial trainings were customised for each batch of students, based on the category or stage of the project that they were in. The reason was to equip them with the proper knowledge and hands-on skills required before actual work on the airplane. The intervention was kept to a minimum to provide them opportunities to experiment and to learn. As in most PjBL that requires a great deal of hands-on work and interpretation of blueprints, errors by novice students were inevitable. Being inexperienced, mistakes became an integral part of the learning process, and prompt corrective actions and encouraging words were essential to avoid derailing the project and to maintain students' morale. It was essential for the tutor to accept and not flinch at the slips and missteps committed by the students and to turn the mistakes into a source of learning for them.

Students developed good work ethics and learnt professional integrity by accepting responsibility. A safe learning atmosphere was cultivated whereby students admitting their mistakes were not ashamed of their errors. This enabled them to complete building the airplane in a safe manner as they learnt how to rectify defects professionally and acceptably based on industry standards. Pellegrino and Hilton (2012) noted that through this process, the students moved from being a novice in a particular skill or subject area to become an expert.

Different Skill Sets

Building the airplane was not just about installing 10,000 rivets and putting the parts together in a seamless manner. There were components from different original equipment manufacturers (OEM) with no clear instructions on the interface. Tasks that involved controls between the powerplant and cockpit instruments caused numerous work stoppages as students had to design and to customize the installation. Other challenges arose from the "glass cockpit" navigation systems that required extensive testing and troubleshooting. The entire experience taught the project team the importance of resilience and students learnt valuable lessons in communicating with OEMs for instructions and software programming as well as participating in forums created by airplane enthusiasts from around the world for solutions. Through experiencing real-world interaction, students could understand and make better connections from the classroom to the workplace.

Through all these challenges, the students navigated the numerous roadblocks and turned them into learning opportunities.

Motivation - Feedback by students

The concept of motivation is derived from the Latin word "movere" which means to move. This project not only sparked interest, but it also motivated students to act on their interest and to persevere in the face of challenges. Project observation showed an increase in the level of student engagement. The DAAT's management team made the following positive observations regarding the PjBL instructional approach:

- All the students participated actively throughout the 12 weeks project period.
- Students were enthusiastic and continued to support different teams even after they had completed their assignments.
- When the project started, many students requested to take part in the airplane building PjBL.

PjBL is an effective teaching methodology as it had a significant impact on the students' intrinsic motivation to learn. It created independent thinkers and learners, and the outcome was the greater conceptual understanding by self-directed learners (Warren, 2016).

From the qualitative feedback collected, the responses were positive, and almost all expressed that their hand skills had improved, and that they are more confident in applying the skills acquired. Some feedback from students are shown as follow:

- "The best experience that I had from building the plane is to work together with my buddy, and this was the best hands on experience that we had throughout our poly life" (Nov 2014).
- "To build an airplane is something which I've never thought of doing but it has made me who I am today" (May 2015).
- "I am glad that I decided to take on this challenging task as my final project. This project strengthens my will and passion for being an aerospace engineer…" (Aug 2016).
- "It's been a very good experience to be able to build aircraft. NYP is the only poly that allows us to build an aircraft. It is hard to build, but nothing comes easy. With this experience of building CH750, I now know what I want to do in the future" (Aug 2017).
- "I have gained an insight of what is it like to work in the aviation industry through activities such as spares inventory control, task cards certification so as to keep track of what is being done for the aircraft and to use the correct manuals or drawings" (Feb 2018).
- "I feel that the CH750 was the most interesting thing I had done compared to my peers as I had a lot of hands on experience…" (Aug 2018).
- ".. working on the CH750 aircraft has been an overwhelming experience because it has given me a chance to try out things that I have never done before. Troubleshooting helped me to learn all the new things, and it made me a better person as I am more perseverance now" (Nov 2018).
- "Overall, I felt that this FYP taught me a lot and prepare me for the challenges that I may face in the future" (Nov 2018).
- "Working on this project has allowed me to apply what I have learnt in class practically. It allows us to not only visualise but really able to understand how a plane works as this is a functional plane... While working on the plane, students will learn how to think on the spot and think of ways to solve problems while providing us with a means to develop and test our technical skills. Overall, I feel that this project provides us with an opportunity to grow technically and theoretically" (Dec 2018).

Conclusions

For PjBL to be successful, it requires research, planning and diligence from all involved, and when carried to its fruition, it will be recognized for its contribution to preparing students in pursuing their area of specialisation.

From the students' feedback, the relationship between the quality of the PjBL experience and the interest generated in the respective activity is directly proportional. The decision by DAAT to use "building an airplane" as the central vehicle of instruction had positive effects on students' engagement, motivation, and confidence in their own ability. This PjBL has offered a high degree of challenge for all involved and is aligned with NYP's strategic goals of cultivating Innovative and Enterprising attributes as well as a Can-Do spirit in our students and staff.

Figure 3: From Conceptualization 2014
(Source: Zenith, with permission)

Figure 4: To Completion (2018)

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Real-time Learning Analytics for Online Synchronous Learning

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Abstract

With the widespread usage and availability of Internet-connected digital tools, educators have adopted online learning as a staple method to conduct lessons. Online learning is becoming mainstream in today's learning. With online learning, there is a lack of human interaction between the learners and the educators. Online synchronous learning (OSL) mitigates this issue; however, the limited frequency and duration of synchronous online learning make it challenging to maximize motivation and support to all learners. Numerous researches have shown that such human interaction is instrumental in engaging learners as well as aid learners in understanding the content. To address this need, OSL could be used to both leverage the affordances of digital technology, as well as provide a medium for learners and educators to connect.

In this paper, we present a real-time learning analytics system, EXSERLAN that is seamlessly integrated into the teaching and learning materials used for a synchronous e-learning lesson. Learners' responses to questions to assess their understanding of the materials are automatically captured with no friction for learners, and data could be presented in real-time visualizations to educators to track learners' understanding and enable immediate feedback. A comparison of learners' qualitative feedback and the number of targeted interventions by the educator was made between control and experimental lessons. Targeted interventions are defined as moments when educator spot a learning gap or misconception and intervene immediately to address the issue. The experimental lessons where educator used EXSERLAN to capture and visualize the interactions made by the learners with the learning materials yield better qualitative feedback as well as record a higher percentage of targeted interventions. The results show the use of such a system is successful in not only engaging learners but also deliver more effective lessons.

EXSERLAN is novel in its approach. Firstly domain-neutral: it can potentially be used by any educator for any discipline. Secondly, it does not require much technology know-how on the part of educators to deploy and use. Lastly, EXSERLAN could be embedded into major Learning Management Systems (LMS), from which the system could extract information like the users' names from the LMS automatically.

Keywords: *Real-time, learning analytics, data visualization, synchronous e-learning*

Introduction

Learning analytics has garnered much attention from educators and schools alike with its potential to offer previously unobtainable insights to learners' learning. Feedback or analytics performed on learners' data can be roughly categorized into three types: summative (at the end of the semester), delayed (after the lesson, be it on the same day, within the week or at the end of a term) and real-time. Most feedback or analysis fall into the first two categories because the analyses results are not immediately fed back to educators or learners at the point of teaching or learning.

A viable approach to mitigate this difficulty is to rely on digital tools. Data collection in the digital realm is much more streamlined as it could depend on software or LMS. Online synchronous learning, supported by videoconferencing and web chats, has the benefit of engaging learners more than online asynchronous learning as both learners and educators attribute the experience with more social interaction. Learners also reported that they felt less frustration since their questions could be addressed in real-time. It seems, hence that online synchronous learning could marry the best of both real-time engagement as well as maximize on the affordances of digitalization. However, based on current mainstream technology, it is still dependent on learners' active feedback through the video or web chat, that educators can capture learning gaps and address them.

In this paper, we propose a domain-neutral real-time analytics system, **Ex**tensible **Se**amless **R**eal-time **L**earning **An**alytics (EXSERLAN) that was built on open-source technology that can be used by non-tech-savvy educators easily in the online synchronous environment to capture and visualize learners' interaction automatically in real-time. The system comprises a learner app where learners' interactions with the app are captured and pushed to the cloud, and the data is fed back into a tutor app in real-time. The tutor app has numerous data visualizations that educators can use to analyze learners' responses. This system empowers educators to be able to gather data from all learners "behind-the-scene", instead of relying on the learners' own initiative to voice out their needs or concerns.

Background

One definition of learning analytics is the "measurement, collection, analysis and reporting of data about learners and their context for the purpose of understanding and optimizing learning and environments in which it occurs" (LAK, 2010). The rise of technology usage in schools have made the use of learner-produced data and associated analytics more available to the administration and educators alike, who used the data to discover connections, and to predict and advise on learning (Siemens & Baker, 2012). Strategies to embark on learning analytics could span from predictive modelling and patterns discovery (Romero & Ventura, 2007), to simply descriptive statistics and data visualization (Duval, 2011).

Data visualization is a comparatively low-cost entry into the realm of learning analytics to improve teaching and learning. One reason for the popularity of data visualization is its ease of understanding by non-analytical background administrators and educators (Williamson, 2015). Visualization is a powerful means to influence decision-making as humans are predominantly visual in nature, even more so when we are considering using learning analytics in a real-time basis, as it would be unreasonable to require educators to pore over tables of data to make informed decisions on the spot.

Many educational institutions use LMSs such as Blackboard and Moodle to manage users' access and act as online repositories for course materials. LMSs empower the institutions by making large-scale educational data collection relatively seamless. However, most LMSs do not have the capabilities to do data reporting and visualization in real-time in a user friendly manner, leaning instead towards providing a centralized database and repository.

To circumvent the difficulties present in current LMSs in furnishing real-time analytics, Choi at al. (2018) deferred to using clickers and free cloud services like Google Forms and Google Sheets. However, this approach neglects the benefits and affordances that a LMS provides to both the administration and the educator. That is why Poon et al. (2017) proposed using visualization techniques to mine for information based on log data from LMSs. Nonetheless, the suggested approach only offered delayed analytics at best, far from the real-time analytics this paper proposed.

LMSs often come equipped with online synchronous teaching and learning capabilities. Online synchronous learning allows for real-time participation by a large group of learners without limitation to a physical location (Seifert, 2019). It is hence invaluable for the business continuity of a school in case of emergencies where the school have to suspend face-to-face lessons. Research has shown that learners report less frustration during synchronous lessons since this mode of learning allows their questions to be considered in real time, and learners report that they feel less isolated (Martin et al., 2017).

In terms of learning analytics frameworks, some frameworks are too specific in their scope, focusing on e.g. educational virtual worlds (Fernández-Gallego et al., 2013) and literacy (Dawson & Siemens, 2014). Wise et al. (2016) proposed a framework to bridge the "middle space" between analytics data presentation and action based on the analytics, but their framework do not look into the nuances of levels and frequencies of analytics. Bakharia et al. (2016) put the teacher in the center of their framework, which, in another sense, relegated the learner to the periphery of their methodology. Wolfgang et al. (2012) suggested another framework that zoom into critical dimensions of learning analytics, even considering stakeholders, internal limitations and external constraints, but similarly, not much reflection was given to different levels of analytics and the speed at which data is collected and analytics are performed.

Proposed Learning Analytics Framework

The team adopted a holistic view of how learning analytics and the core task of teaching and learning fit together and proposed a full-cycle learning analytics framework (see Figure 1).

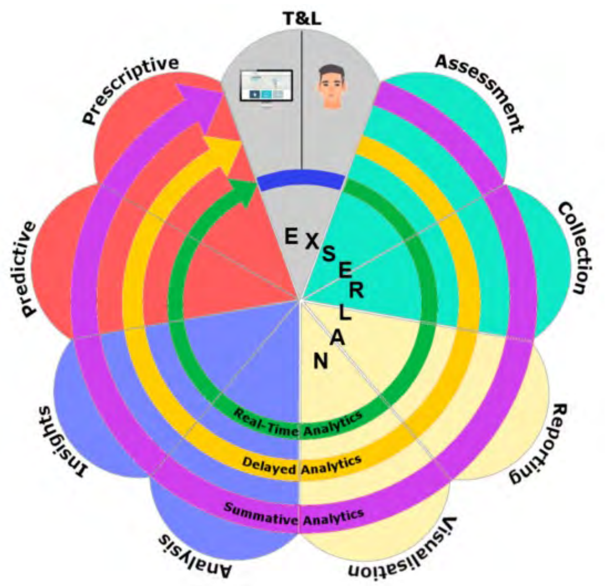

Figure 1: Full-cycle framework for Learning Analytics

The framework is divided into 9 sectors, and apart from the top-most sector of Teaching and Learning (T&L), the rest of the sectors represent different stages and levels of learning analytics. The rest of the eight sectors are grouped into pairs, and explained below.

Teaching and Learning (T&L)

As shown in the diagram, the team considered as core to the full cycle of learning analytics the sector of T&L, which includes preparation of the course materials by educators, and the actual delivery of the lesson to the learner, be it via face-to-face or online means.

Assessment and Collection

As the framework depict, data is generated by learners in the assessment step (be it formal or informal, diagnostic, formative or summative), and collected subsequently either through manual means. These first two steps do not constitute actual data analysis, but are essential stages without which analytics could not commence.

Reporting and Visualisation

Learning analytics actually commence when the data is being reported back to the educator or administrators. Often, the data is presented in tabular form, but a more useful approach would be to use visualization for faster and more impactful decision-making based on data.

Analysis and Insights

With raw data at hand, educators or data analysts could then inspect, clean, transform or model the data to perform descriptive analytics. The goal of such analysis is to help educators to discover insights on learners' learning, and support the educators or administration in decision-making. In the process, it is hoped that questions could be answered, hypotheses tested and theories proved or disproved once the data is analyzed.

Predictive and Prescriptive

As more data is gathered, predictive modellings could be employed to predict trends in individual learner's learning or extrapolated to aggregated behavior of a group of learners. Finally, presciptive analytics could be employed, which goes beyond simply predicting future outcomes to suggest actions that could benefit from the predictions.

This depiction of learning analytics into distinct stages is not meant to imply that all stages must be performed. Learning analytics could be performed at different levels e.g. a quick analysis could stop at Visualisation, while a more detailed one could go all the way to Predictive analytics.

In the framework, we also show three almost-complete circles of analytics cycle.

Summative Analytics

Analytics performed at the end of a teaching semester or academic year is considered summative analytics as it can utilize all the data collected whether formally or informally, from in-course to terminal assessments. The richness of the data is shown in thickness of the width of the circle. The circle is incomplete as day-to-day T&L activities are detached from the insights gained from summative analytics for the nature of this kind of analytics occur after all the lessons are over.

Delayed Analytics

Slightly thinner in width is the incomplete circle of delayed analytics, which is done after every term, every week or at best after every lesson. The data available is not as rich as that in summative analytics, for the educator only has termly, weekly or at best, the logged data of learners from each lesson. The frequency of delayed analytics is faster than that of summative analytics, however, and it can be done multiple times within a course. Insights gained can be fed-back to the actual learners themselves, not immediately, but at most during the next lesson. There is still a break between T&L activities and delayed analytics as the analysis and actions to take come after the lesson.

Real-time Analytics

The thinnest incomplete circle is the real-time analytics and it contains the optimal granularity of data of all three cycles. The potential of real-time analytics is the learning gaps or concerns of learners can be addressed immediately. This makes for more engaged learners and more effective lessons. To achieve this quick feedback cycle, data needs to be captured on-the-fly and acted upon as soon as possible. Educators armed with a real-time analytics system will thus be empowered with immediate data that they can use to improve on both teaching and learning. Issues related to a high pupil-teacher ratio could also be mitigated as the educator now has many “eyes” on individual learner’s progress

All three cycles of analytics have a part to play in a comprehensive learning analytics approach, but real-time analytics is currently the most lacking yet most promising category of learning analytics. In the following section, we are going to described an **Ex**tensible **Se**amless **R**eal-time **L**earning **An**alytics (EXSERLAN) system that can not only enable real-time analytics, it has also been proven to be frictionless from T&L activities all the way to visualisation. In other words, the system is embedded within teaching and learning materials, and data is assessed, collected, reported and visualised automatically, in real-time, with no switch of tools for both learners and educators.

EXSERLAN

EXSERLAN is a real-time learning analytics system that provide immense value in classroom teaching and online synchronous learning. In the traditional classroom, there is minimal sensing of learners' understanding of the lesson and feedback is only given at the end of the course. It allows educators to effectively track the level of understanding of learners in real-time and intervene timely without interrupting the lesson. Learners access their online mobile-optimized lesson where data are captured during the lesson and visualized in real-time, to monitor learners' progress.

EXSERLAN mainly comprises of 2 components, the learner app and tutor app. The team customized an open-source software called Adapt Learning Authoring Tool (Adapt) that helps educators develop mobile-optimized web lessons suitable for classroom or online learning with different types of assessment componments 'checkpoints' (Figure 2). The mobile lesson is exported into a SCORM2 package that can be embedded into any major LMS.

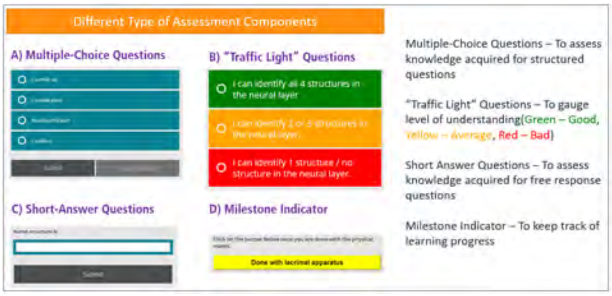

Figure 2. Type of Assessment Components to capture student's progress and interaction

EXSERLAN Tutor App can be accessed from both desktop and mobile browsers. It provided the educator with a dashboard (Figure 3) to visualize the learners' responses to these assessment components in real-time and track their progress. Numerous visualizations are available to help educators make quick yet decisive actions in the classroom. The educator can analyze responses to a question at learner level or classroom level with aggregated views (Figure 4).

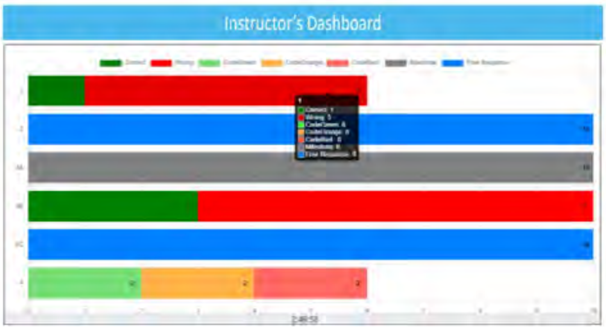

Figure 3. EXSERLAN Tutor App - Dashboard

Figure 4. EXSERLAN Tutor App – Learner and Classroom view

Methods

Participants in the present study consisted of two groups of Year 1 full-time Polytechnic learners from the School of Information Technology, amounting to 38 learners in total. All of whom were learners for the module Digital Business where key concepts and theoretical understanding are required. The study was conducted during a Business Continuity Exercise, where they did not have to attend lessons in the physical classrooms but instead had attended online synchronous lessons via Blackboard Collaborate.

To evaluate the use and effectiveness of the real-time analytics in class, a before-and-after design was taken for the research methodology. Learners first underwent almost an hour of lesson listening to the educator share over a video conference call. They could raise questions via web chat, and they had to follow the lesson using the EXSERLAN learner app. The educator, in the first half of the lesson, did not make use of the EXSERLAN tutor app, and hence could not benefit from real-time analytics. In the next hour, learners used the same tools for a different chapter of the topic, but the educator is now not only viewing the real-time dashboard of the EXSERLAN tutor app, but also showing the dashboard to learners via the screen sharing function of Blackboard Collaborate.

Learners' interaction data with the learner app was thus captured for both the non-real-time session as well as the real-time session. Interventions by educators that were targeted at moments when learners faced difficulties were recorded for both sessions. For example, if Learner A answered a question wrong, it would be captured in the database. Without the help of the real-time visualization dashboard, the educator could only rely on the web chat function and on the learner's willingness to voice out to capture that information. However, with EXSERLAN, the educator could see aggregate data on how many learners got the question right or wrong immediately, as well as drill down into individual learner's response.

Lastly, each learner was also surveyed to answer the following questions after the non-real-time analytics session, and after the real-time analytics session:

On the scale of 1 (least) to 10 (most),

1. how would you rate the level of ***engagement*** you experienced in the class?
2. how would you rate the level of ***effectiveness*** of the class in helping you understand the topic for the week?
3. how would you rate the level of ***helpfulness*** the educator was to you, in terms of clarifying your doubts, providing thorough explanations of the lesson contents etc?

While the usual method for evaluation is to look at the average score of each question asked, a more stringent (or accurate) way of evaluating the score for the questions is to adopt the Net Promoter Score (NPS) calculation method. The NPS is a customer loyalty metric developed in 2003 by management consultant Fred Reichheld of Bain & Company in collaboration with the company Satmetrix (Reichheld, 2003). Although NPS is usually used to compare satisfaction with brands, it can be deployed in this case as it tackles satisfaction related concerns.

Depending on the feedback received, three categories of people can be distinguished:

- *Promoters = respondents giving a 9 or 10 score*
- *Passives = respondents giving a 7 or 8 score*
- *Detractors = respondents giving a 0 to 6 score*

The NPS is finally calculated as the difference between the percentage of promoters and the percentage of detractors.

Lastly, quantitative data in the form of number of interventions were needed (e.g. when learners got any question wrong, or they indicated they needed help via the Traffic Light tool), and the number of interventions given by the educators were recorded.

Results and Discussion

For each of the metrics, the average score was calculated. All 3 metrics received an average score of 7 at pre-implementation phase, an average score of 8 at no real-time intervention phase and an even much better score of 9 at the real-time intervention phase (Figure 5).

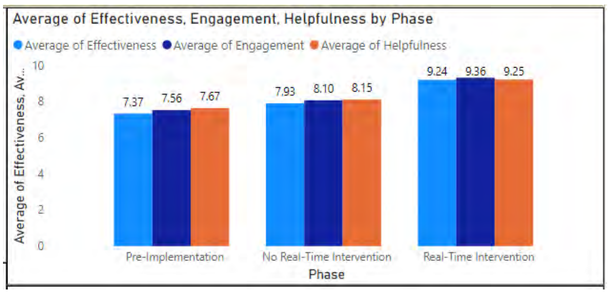

Figure 5. Average of the Effectiveness, Engagement and Helpfulness survey.

A quick conclusion tells us that real-time intervention does help with online synchronous classes where learners find effectiveness, engagement and helpfulness at class. However, one might argue the significance of the differences among the scores, hence NPS calculation is employed to further ascertain impact of real-time analytics application during class.

The NPS results demonstrated that real-time analytics in class has a significant impact on the perception of effectiveness, engagement and helpfulness experienced by the learners, as shown in the chart below (Figure 6). At the pre-implementation stage, the NPS for all 3 questions are below 10%, which increases to around 25% when users were using the learner app but the educator was not giving real-time intervention. Finally, when real-time intervention was given by the educator, NPS shoots up dramatically to be all above 80% for all 3 questions.

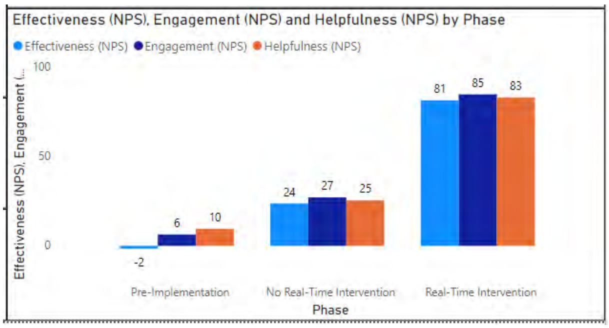

Figure 6. NPS of the Effectiveness, Engagement and Helpfulness survey

Table 1 shows the quantitative results gathered using EXSERLAN. We noted that the number of interventions that the educator could take that were targeted at learning gaps of learners during class was a paltry 6%, as only learners called upon or more vocal would have their needs addressed. Armed with a real-time view, the educator could capture 79% of the learning gaps and address them immediately to the whole class.

Table 1. Quantitative results gathered using EXSERLAN Learner app.

No real-time view			Real-time view		
Interventions required	Targeted Interventions given	Proportion captured	Interventions required	Interventions given	Proportion captured
263	16	6%	370	293	79%

Qualitative feedback were collected from the learners as well. The majority of comments showed that they found that the real-time feedback and visualization made the lessons much more engaging and useful than lessons without real-time analytics. They also felt that the lessons were more effective with real-time feedback, as they could get their misconceptions addressed immediately in class.

Conclusions, Limitation and Recommendations

In this paper, the team presented EXSERLAN, a real time learning analytics system, and evaluated the use of the system in online synchronous classroom. The study showed that learners were more on-task and felt that the face-to-face lessons were effective and helpful to their learning when they could have their learning gaps addressed in real-time. Educators appreciated the real-time system for providing them with immediate insights they can use to narrow students' learning gaps in class.

A limitation of real-time learning analytics is that it is difficult to apply effectively to large group lectures. To mitigate this limitation, EXSERLAN is designed to show not only individual responses, but also aggregated class feedback. Educators can use the aggregated responses visualizations to give feedback to the whole class during lesson itself. The educator could use EXSERLAN as a delayed analytics tool after the lesson by reaching out to selected learners who require more interventions using data captured during the lesson.

In conclusion, the findings of the study showed that with real-time analytics and intervention afforded by EXSERLAN, there was a 73% gain in the ability to addressed learning gaps compared to the traditional approach where there was no real-time view. Thus, our proposed approach with EXSERLAN is effective and it is a breakthrough in the T&L space in online synchronous classroom where learner's doubts could be answered even before the class ends.

Acknowledgements

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ONLINE INTERNATIONAL DESIGN WORKSHOP: DESIGNING A TEAROOM TOGETHER

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Abstract

Since 2015 the NIT Akashi college has hosted an international design workshop where students from Brazil, Hong Kong, and Germany developed a design for a tearoom. The design workshop was part of a three-week Japanese Architecture course. However, in 2020 due to the Covid-19 pandemic, international travel became impossible and we could not receive international students. The only solution was to hold the design workshop online.

The online design workshop started in November 2020 and ended in January 2021. It had nine sessions of 90min each, where the students met online and worked together on the design of a tearoom. The workshop had 53 participants and included students from Japan, Brazil, Hong Kong, Indonesia, and Singapore. The platform used for the workshop was Facebook, and the online meetings used Zoom. The students worked in groups of 5 or 6 people, with a maximum of 2 students from the same country in each group. They did the design a tearoom and explained their design using drawings, and a five-minute video presentation. For the Japanese students, this workshop was part of an elective course and they worked together in the same room while having online meetings with their international group members. Two instructors monitored the online sessions and assisted the students when necessary.

This paper aims to offer practical teaching suggestions and to evaluate the efficacy of an online design workshop. It explains how the workshop was organized, the difficulties faced during the workshop, and analyse its results. Here, using information collected from a survey and interview with the participants, we also evaluate the workshop's impact on the students.

Keywords: *online design workshop, international exchange, tearoom, Japanese traditional architecture,*

Introduction

Due to the Covid-19 pandemic, academic activities that involved cross-country traveling, such as receiving international students or sending students abroad, had to be cancelled. Akashi college's architecture department, since 2015 holds a one-month internship program about Japanese Architecture for international students. The main program activity is a design workshop where the international students develop a design for a tearoom with the Japanese students. The internship also has other activities such as field trips and international exchange with Japanese students. Because of the pandemic, it was impossible to receive international students, and we decided to have the design workshop online.

This paper describes the organization and development of the workshop and its results. It also analyses the impact it had on the students based on interviews with the students and the results of a survey, where the students evaluated the workshop.

Planning the workshop

The tearoom or tea house is a building type unique to Japanese Architecture and synthesizes Japanese aesthetics concepts. It is also a tiny building, which makes it the perfect topic for an international design workshop.

The first step in organizing the workshop was gathering the participants. We post on the school website and send a flyer explaining the workshop activities to our partners' schools. The applications to the workshop opened in October 2020, and there was a three weeks application period. The number of international applicants was bigger than expected, and we ended with more international students than Japanese students participating in the workshop. In total, 53 students participated in the workshop: 20 students from Brazil (UFRGS), ten students from Hong Kong (IVE Tsing Yi), one student from Singapore (Nanyang Polytechnic), one student from Indonesia (Diponegoro University), 19 Akashi college 4th-year students, and because the number of international students 2 Akashi college 5th students also joined the workshop.

The workshop is part of a 4th-year elective course, and the online workshop sessions had to happen during the course classes schedule, which was 10:40 am Japan standard time. The time difference was the first obstacle.

The second step was to choose the platform for the workshop. Akashi college uses three LMS, Microsoft teams, Google classroom, and Moodle. However, those platforms are difficult to access for people from outside the institution due to security reasons. Therefore we opted for an SNS platform and used Facebook for exchanging data and

Zoom for the online meetings. First, we created a group on Facebook and added all the participants to this group. Many students did not have a Facebook account, and there was some trouble with joining the group. After having all students on the Facebook group, we divided the students into ten groups. We tried to have the groups as international as possible. Since there were 2 Japanese students and 2 Brazilian students per group, we allowed them to choose who they would like to work with. The first online meeting was on November 4th, and in this Zoom meeting was announced the group members explained the workshop's goals, how they should develop and present their design, and each student made a short self-introduction. The meeting was recorded and later posted on the Facebook group page. The students also created another Facebook group page for each group, and the instructors also joined those smaller groups to support the students. We kept the schedule of the workshop flexible and adapted it according to the students' development. The idea was to keep the workshop short and finish it by December, but the students asked for more time to work, and we extended the workshop until the end of January.

The students were asked to think of a design concept and develop the design for a tearoom. They have to explain their design ideas using drawings, CG, and models. Make a final video presentation of their tearoom, and post the boards with the graphics and the video on the Facebook general group page.

To help the international students understand Japanese Architecture, was posted a video lecture about Traditional Japanese architecture and a paper model of a tearoom and asked them to build it (fig.1) .
The Japanese students also researched modern tearoom examples and posted them on Facebook.

Figure 1: tearoom paper model assignment and student reaction.

Carrying out the workshop

The workshop had nine online meetings. The Japanese students worked together in the same classroom (fig.2) while the international students joined online.

There were some internet connection problems in the begging, and some students from Brazil got confused with the time. The meetings were on Wednesday 10:40 am JST, Tuesday 10:40 pm in Brazil. The online sessions started with a 20 minutes meetings with all participants. In this

Figure 2: Photo of the Japanese students working online.

general meeting was explained the goals for the day and answered the doubt from the students. After that, each group started its independent zoom meeting and worked on its design.

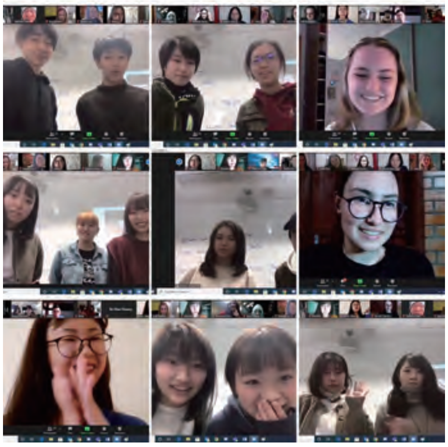

Figure 3: screen shot of the first online meeting

The schedule of the workshop and the goal of each session was as follow:
November 4th: First online meeting
Goal: To explain the objective of the workshop and meet the other participants.
In this meeting, each student introduced themselves and talked about their expectations from the workshop. The students were divided into ten groups, and each group created its Facebook group page.

Figure 4: screen shot of a Facebook group page, explaining the site.

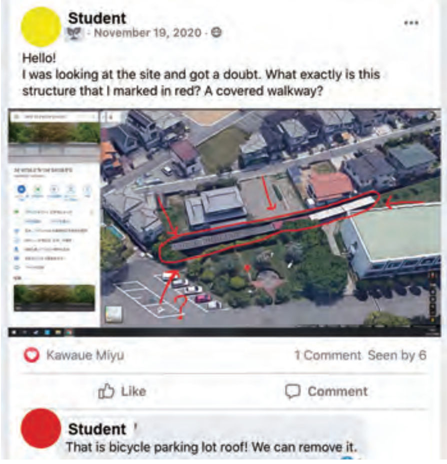

Figure 5: screen shot of a Facebook group page, international student equiring about the site.

November 11th: General Meeting + Groups' meetings
Goal: To understand the site
The site for the tearoom was inside Akashi college ground, and the Japanese used videos and photos to explain the site to the international students.
November 18th (today) General Meeting + Groups' meetings
Goal: To develop a design Concept and drawings (First Sketches) for the tearoom.
On November 25th and December 2nd, there were no meetings because it was midterm exams for the Akashi students. Although the students did not meet online, they exchanged and developed their ideas using the Facebook group.

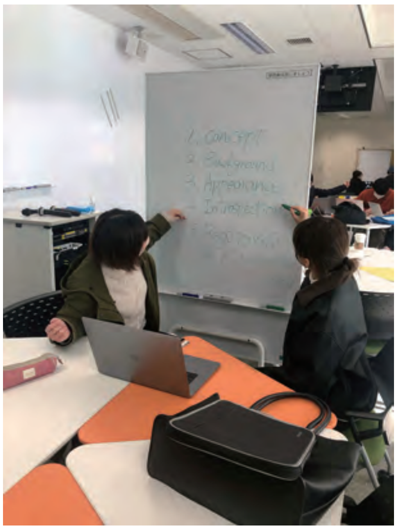

Figure 6: Photo of the students discussing about their design concept.

December 9th General Meeting + Groups meeting
Goal: to Develop and organize drawings and design ideas
On December 16th, there was no online meeting because Akashi students had a school sports event. Here again, the students developed their work using Facebook.
December 23rd General Meeting + Groups meeting
Goal: Finalization of the project, tasks division
Since it was the end of the year, we did a small end of the year online party during the general meeting, and the students exchanged Xmas and New year messages.

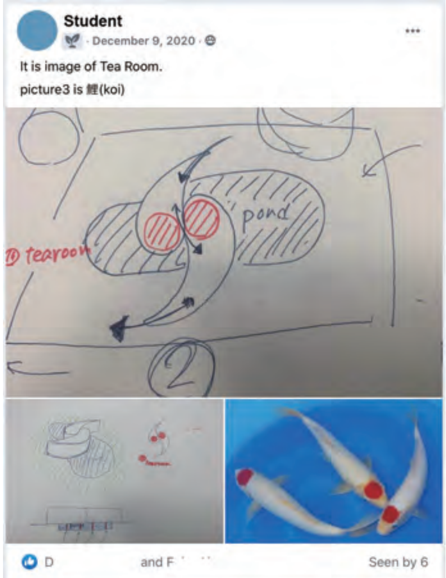

Figure 7: screen shot of a Facebook group page, showing how the students interact and shared their ideas.

January 6th General Meeting + Groups meeting
Goal: Elaborate final presentation Video + Drawings Boards.
During the general meeting, the tutors explained how the students should prepare their final presentation and answer their questions.
January 13th Groups meeting
Goal: work on the final presentation
January 20th: Deadline for uploading the video and boards
There was no general meeting, and the students worked on their presentation. All groups posted their drawing boards and presentation video on the main Facebook group page. The students watched each other's presentations and post comments about the designs.

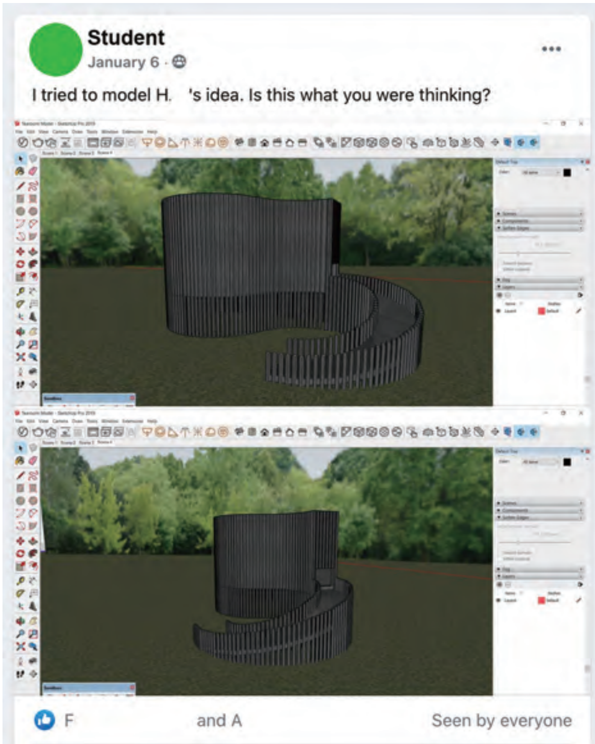

Figure 8: screen shot of a Facebook group page, CG study.

Figure 9: screen shot of a Facebook group page, CG.

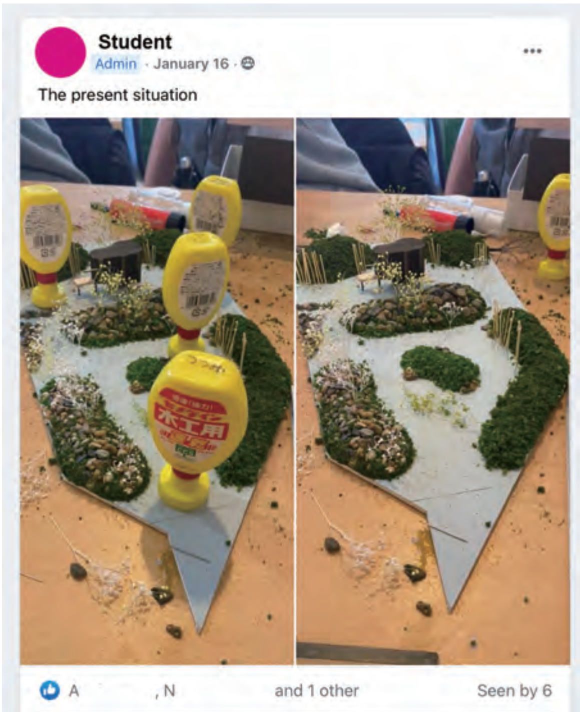

Figure 10: screen shot of a Facebook group page, model.

January 27th: Sayonara meeting
In this last online meeting, the tutors commented on the students' works and evaluated the workshop. The meeting ended with a small "Sayonara" online party, and each student commented about the workshop. Some students got emotive and even cried during the farewell meeting.
Later the students' works were posted on Akashi college's home page, and the presentation videos were organized on a youtube channel.
All groups were able to develop a design concept and ex-

Figure 11: screen shot of a Akashi college home page with the students works.

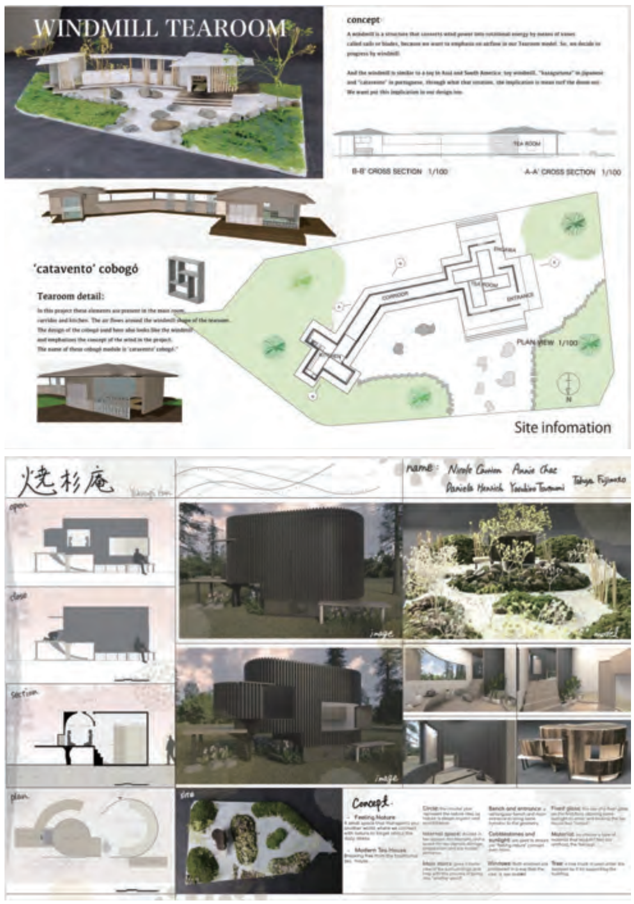

Figure 12: to examples of the students works.

plain their ideas using drawings, CG, and models. Some groups had difficulty communicating, and the instructors had to give them some support. English was the official language of the workshop, but the students mixed other languages, mostly Portuguese and Japanese. Some groups used the Facebook translation function and just posted their comments in their native language. It was interesting to see the students explaining their ideas using handmade drawings and showing them to the PC camera. All the students seemed to enjoy the workshop sessions.

Feedback from the students

After the workshop, the students answered a survey. Most of the students from Brazil learned about the workshop through an e-mail from UFRGS university, while the other international students learned directly from their teacher. 50% of the international students were in their first academic year and did not have much experience with architectural planning or drawing. At the time of the workshop, the students from Brazil were the online ones to had 100% of their classes online. The students from Hong Kong, Indonesia, and Singapore had mixed classes, part online and part presential, while the Japanese students had 100% of presential classes.

The students answered that what motivated them to join the workshop was their interest in Japanese Architecture and Culture, working together with students from different countries, and making new friends. Some students also wanted to use this opportunity to practice English and develop their design skills.

"*I joined the workshop because the theme was really cool and far from my reality, in a time that we could just stay at home was a blessing to have meetings with people from another part of the world! I expected to learn more about another culture and talk to students from other countries, and I got all that from the workshop."*

When asked if the workshop was up to their expectations, 80% of the students answered that it surprised them and that it was more interesting than they expected, 20% of the students said it was ok, and there was no student unsatisfied with the workshop.

Regarding the communication tools, only 90% of the international students were familiar with Facebook and ZOOM, while for most of the Japanese students, it was their first time using Facebook. In addition to Facebook and ZOOM, the students also used other SNS platforms to communicate, such as Instagram and Whatsapp.

All the international students watched the video lecture about Traditional Japanese Architecture and answered that the lecture helped them better understand the workshop.

"The idea that everything, from language to cultural concepts, affects architecture brought me another perspective."

"I really loved the lecture! It was so interesting to know a little bit more about the tea ceremony. And also learn about the architectonic parts (like chigaidana, tokonoma, nigiriguchi...) and their purposes. Even though the video was long, it was light, fun, and not at all repetitive. The paper model didn't make a lot of difference for me, though..."

"I loved the lecture, but the paper model as confused for me and I didnt have time to finished it at the time."

Unfortunately, the paper model was not as popular with the students as the lecture, and only 60% of the international students built the model. From the students' feedback, we can say the explanation about the paper model was insufficient, and it needs to be reviewed.

The workshop had 9 online sessions, and the average attendance of the international students was 90%. Concerning the division of tasks, all students equally participated in the design process. Most international students were in charge of executing the computer drawing and CG while the Japanese students made the architectural models. Most of the students answered that they were satisfied with the tearoom design and what they produced during the workshop.

"I was very satisfied, I believe that our project was very good but there is always that little taste that we could have done something even better."

Conclusion

In conclusion, based on the students' feedback and the product of the workshop, we can say it was a good experience. Having the Japanese students working together in the same room made it easier for the instructors to support them during the activities. Probably the reason why the workshop was a success was that it was partially online and partially presential. The instructors were satisfied with the results, and we intend to repeat the online design workshop next year. We hope the pandemic will end and that we will be able to receive international students again soon.

Acknowledgements

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INCREASING STUDENT INTRINSIC MOTIVATION AND SELF-EFFICACY THROUGH STUDENT INITIATED CAPSTONE PROJECTS

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Abstract

The study examines how students' motivation and self-efficacy can be increased through student-initiated projects as a method of experiential learning. This paper focuses on two recent surveys conducted by the author on 107 final year students, from 3 cohorts, pursuing the Diploma in Chemical Engineering. The findings confirm the general observations that through allowing students to self-initiate capstone projects, both the levels of student intrinsic motivation and self-efficacy will increase.

Keywords: intrinsic motivation, self-efficacy, capstone projects, Self Determination Theory, autonomous.

Introduction

Without any natural resources, Singapore's success depends almost entirely on her citizens. Since the city-state became an independent nation in 1965, education has always been an area of focus. In 1997, the then-Prime Minister Goh Chok Tong announced the Ministry of Education's (MOE) vision of "Thinking Schools, Learning Nation" (TSLN)". For more than two decades, this vision has directed the ministry in its mission as well as goal and policy setting such as "Teach less, learn more". In September 2018, Education Minister Ong Ye Kung announced that the nation is now moving into the next phase: "Learn for Life", which is a value, an attitude and a skill that citizens need to possess. (Straits Time, 2018).

School systems need to recalibrate the balance between academic rigor and a love of learning as it is the cradle of thinking students and adults. This spirit of learning should accompany the students even after they leave school.

However, in schools, motivating students to learn seems to be a challenge for teachers globally. Even among seemingly motivated students, motivation is largely extrinsic, driven by grades or better career prospects rather than intrinsic motivation, which focuses on satisfaction, or pleasure in performing a task (Lei, 2010). According to Orvis et al. (2018), the extrinsically motivated student does an activity, because it leads to a separable outcome or consequence, such as obtaining a reward or avoiding a punishment. The intrinsically motivated student on the other hand, comes to class because of the thirst for knowledge. The student does an activity because it is inherently satisfying and enjoyable. There are no separable outcomes or contingencies that initiate and maintain this behaviour; rather, intrinsically motivated behaviors occur spontaneously and are accompanied by experiences of interest, excitement, and enjoyment.

Self-efficacy is the belief we have in our own abilities to achieve while motivation is based on our desires to achieve (Ackerman, 2020). Self-efficacy and motivation are deeply intertwined but are two separate constructs.

When a motivated student takes on a challenging task and experiences success, self-efficacy increases and this will provide a further boost in motivation for the students to continue learning and making progress. A study by Saracaloglu and Dincer (2009) found that students' self-efficacy positively influenced academic motivation and performance.

Self-efficacy and motivation to learn are hence the important factors that affect the academic performance and learning of an individual/student. Students with high self-efficacy are more likely to challenge themselves and be more motivated to succeed when faced with potential failure, as opposite for students who have low self-efficacy (Vanhaltren, 2016)

Purpose of the Current Study

This research explores the effects of allowing students to craft or ideate their own Capstone projects with their intrinsic motivation and self-efficacy.

Table 1: *The Self-Determination Continuum*

Low Autonomy Low sense of control			→ High Autonomy High Sense of Control			
Amotivation	Extrinsic Motivation			Intrinsic Motivation		
	External Regulation	Introjected Regulation	Identified Regulation	To Know	To Accomplish	To stimulate
Perceive incompetence View goals as unimportant or of low value	External Rewards or punishment	Internal rewards or punishment	Personal importance valuing	Interest	Enjoyment	Inherent satisfaction

Background

Importance of Self-Efficacy

Self-efficacy is a person's belief about whether s/he is capable of successfully completing a given task. The task might be learning a new skill, baking a good cake, or earning a high grade on an examination (Greene, 2017).

Lent et al. (2008) showed that there is direct effect of self-efficacy beliefs on academic achievement. Students with high self-efficacy have greater academic expectations and display better academic performance than those with low self-efficacy.

Fratturaar (2018) further states that students with a strong sense of self-efficacy do not shy away from difficult tasks with impending failure. Instead they show increased and sustained efforts to be successful. They also approach difficulties or threatening situations with confidence that they have control over them.

Conversely, students who doubt their ability to accomplish difficult tasks see these tasks as threats and give up quickly. They have low aspiration and weak commitments to the goals they choose to pursue. They maintain a self-diagnostic focus rather than concentrate on how to perform successfully and failure is hence often inevitable (Bandura, 1993) .

Importance of Motivational Orientation

While most theories of motivation view motivation as a unitary concept, Ryan and Deci (2000) link personality, human motivation and optimal functioning in the Self-Determination Theory (SDT) that they developed. They posit that people vary not only in their levels of motivation (how much motivation) but also in the orientation of that motivation (what type of motivation) (Ryan & Deci, 2000)

According to the SDT, motivation can be categorised into three broad categories, namely amotivation (AM), extrinsic motivation (EM) and intrinsic motivation (IM). These three categories exist along on a continuum according to the level of autonomy underlying the motives behind behaviours. (Ryan & Deci, 2000). Table 1 illustrates this continuum which is based on Ryan & Deci (2000).

Amotivation (AM) is a state of lacking any motivation to engage in an activity due to perceived lack of competence or a failure to value the activity or its outcomes. (Jessica et al., 2018)

Extrinsic motivation (EM) drives one to do things for tangible rewards or punishment. EM is further subdivided into three subscales and differ in the degree to which they are internalized. The least internalized type of extrinsic motivation is external regulation (EM-ER), where the student is motivated mainly by external rewards or punishments. Next is introjected regulation (EM-IN), in which the student is motivated by internal rewards or punishment such as pride or guilt. The third subtype of extrinsic motivation is identified regulation (EM-ID), in which the student is motivated by the value or importance of the activity. (Orvis et al., 2018)

With intrinsic motivation, the student does an activity because it is inherently satisfying. There are no separable outcomes or contingencies that initiate and maintain the behaviour. Within the SDT perspective, intrinsic motivation is likewise divided into the three subscales: intrinsic motivation to know (IM-TK), toward accomplishments (IM-TA) and to experience (IM-ST). IM-TK is seen when a student undertakes a task for the satisfaction experienced while learning something new. IM-TA occurs the driver is for the pleasure of accomplishing a task. IM-ST transpires when an individual engages in a behaviour in order to experience stimulating or exciting sensations (Orvis et al., 2018).

Many research studies, such as the one by J. Ogrodnik (2018), have confirmed and accepted the hypothesis that motivational orientation differentiates pupils' school achievements. In particular, students who reported more intrinsic motivation, were more likely to report a higher level of achievement. (Bryan et al., 2011)

Context

This segment provides the contexts and rationale for the strategic selection of module to support students' intrinsic motivation to learn. Some years back, the Diploma of Chemical Engineering introduced the Chemical Product Design suite of modules when chemical product design was increasingly being regarded as a new paradigm in chemical engineering. The suite comprises 3 modules, namely: Introduction to Chemical Product Design (ICPD), Chemical Product Design and Development (CPDD) and Capstone Project. Students take ICPD and CPDD over two semesters in their second year of study and take the Capstone Project module in their final year. The ICPD and CPDD modules aim to equip the students with essential concepts and tools for chemical product design. In these modules, students are introduced to brainstorming tools such as SCAMPER and troubleshooting techniques such as TRIZ. Students are also guided on how to carry out literature search and develop research hypotheses. In the Capstone Project module, students pursue independent research on a question or problem. It is a multifaceted assignment that serves as an integrative experience for students at the end of the Chemical Engineering Diploma program. Learning is entirely self-directed with guidance and feedback being provided periodically by the project supervisor who can be a SP teaching staff or a staff member from a partnering company.

For ICPD, students are given broad topics to choose from and work on. Some of these topics are: "Energy Crisis and the chemical engineer" and "Role of Chemical Engineers in the face of Water Scarcity Challenges". In CPDD, students can choose to continue working on the project that they developed in the preceding ICPD module or work on an entirely new topic. The focus of the CPDD module is to develop and hone the various skills and techniques in chemical product development through refining and developing product design specifications. Students are also required to create a prototype with limited functionality and a design portfolio.

For the Capstone Project, in traditional offerings, students worked in groups of 3 to 4 on projects or topics that were ideated and developed by the teaching staff. There was an obvious discontinuity between the earlier two modules and the Capstone Project module as in the latter, students chose from given projects instead of ideating a project topic to work on. This discontinuity was due to the belief that ~~the~~ student-initiated projects would not be of good quality to justify the allocation of precious monetary and laboratory resources. They were also deemed as unlikely to be good enough for external competitions.

As for the allocation of projects to student groups, the project coordinator compiled the synopses of all the projects and released them to the students two weeks before the project allocation day. While ideally projects should be assigned to student groups who can justify in writing why they should be allocated the project, the amount of resources required is enormous and thus projects were allocated to the student groups by sortition. Students indicated the top 3 project choices on a form. When 2 or more groups of students indicated interest in the same project, a lot was cast to determine which group got to work on the project.

Once assigned the project, the students were briefed by the project supervisor on the general project objective and hypothesis. The students then carried out literature review and subsequently defined the scope of their projects. The students worked on the project for 12 to 15 weeks, periodically guided by the project supervisors and laboratory technical executives (TE), to produce a written project report and deliver a project presentation to a panel of teaching staff.

From the building up of skills-set in the suite of module, Capstone Project was identified to have the potential to be re-designed to incorporate the key elements of intrinsic motivation.

Module Redesign

The Capstone Project module was redesigned with the theory of self-determination by Ryan & Deci (2000) that identified autonomy and connection as two of the three basic requirements for increasing students' intrinsic motivation as the key reference. Ryan and Deci (2002) maintained that the more autonomous the students perceive themselves to be in activities, the more intrinsically motivated they will be. The third component: competence, is already an element in the traditional offering of the module where students, by carrying out investigative and/or engineering design works, acquire technical competencies. The salient changes in the redesign are described in this section.

A new graded assignment was introduced in the Chemical Product and Development module (CPDD) where the second year students are to ideate a capstone project idea and develop a project proposal that must include a hypothesis, a brief methodology and expected resources and facilities required. The module lecturer gave brief advice regarding the practicality of the projects being carried out in the institution's laboratories. This process allowed the students to reflect deeply about issues and problems that they have strong connections with. Being able to work on topics of their choice would increase intrinsic motivation by meeting the requirements of both autonomy and connection.

During the vacation (before they start their final year of studies), the student groups worked with the project coordinator (myself) to finalise the project proposal. As a project coordinator, I played the role of the gatekeeper, to ensure that the project quality or scope is appropriate for the Diploma and up to mark for external competitions, if any.

I also provided the students with information ranging from the availability of facilities to whether the school has the legal license to purchase and use a certain chemical.

The period of dialogue to finalise the projects was extremely stressful for the students as they saw their project proposals being scrutinized or rejected. This period was also extremely time consuming for the project co-ordinator; handling 16 groups of students at the same time and very frequently, had to consult other colleagues on some of the topics or questions that students raised.

Once the project proposal review was completed, the students were assigned a project supervisor. The assignment of project supervisors was based on the project topic and the expertise of the staff. Thereafter, the students worked on the project for 12 to 15 weeks, periodically guided by the assigned project supervisors and laboratory technical executives (TE). Students had to produce a written project report and deliver a project presentation as in the traditional offering of the module.

Methodology

To assess whether allowing students to craft out or ideate their own capstone projects can increase students' intrinsic motivation and self-efficacy, a multifaceted study was carried out. Students from 3 different cohorts were surveyed. The profiles of these students are summarized in Table 2.

Table 2: *Profile of Students participating in the study*

Cohort	Cohort Characteristic with respect to Capstone Project Module	Student Number
AY2018/2019	Before pilot run; students completed traditional Capstone Project module	17
AY2019/2020	Completed pilot run, students completed new Capstone Project module	42 **19 of them also took part in the self-efficacy study*
AY2020/2021	Students just started embarking on Capstone Project journey from March 2020.	48

The academic motivation survey (Vallerand et al. 1992) was administered in May 2020 to AY2020/2021 third year students taking the Capstone Project module and AY2019/2020 students who had completed the Capstone Project module in March 2020 and have recently graduated. No identifying information was collected and no incentives were given for participation. The survey was conducted using Google forms due to Covid-19 campus closure. The participants for the study were 46 students from the 2019 cohort (freshly graduated) and 48 for the current 2020 cohort.

The survey consisted of 28 Likert-scale items adapted from the Academic Motivation Scale (Vallerand et al. 1992). Cronbach's alpha (α) was computed to assess the internal consistency or how closely related a set of items are as a group. In general, a low alpha appears if the essentially τ-equivalent model assumptions are not met while a high value of alpha (> 0.90) may suggest redundancies and that the test length can be shortened. A Cronbach's alpha (α) score greater than 0.70 indicates moderate internal consistency in the measure of classroom rating scales (Tavakol, M., Dennick, 2011).

To assess students' self-efficacy, another online survey was conducted for students who have completed the Capstone projects, to understand how their capstone project experience have affected their self-efficacies. 19 students from the recently graduated cohort (AY2019/2020) and 17 from the preceding cohort (AY2018/2019) took the survey.

For this survey, I adopted the same approached as Banfield and Wilkerson (2014) by using Albert Bandura's guide (Pajares, F. & Urdan, T. C. 2006); to construct the self-efficacy scales. Since perceived self-efficacy is concerned with perceived capability, Bandura stressed that the questions should be phrased in terms of ***can do*** rather than ***will do***. The word "can" is a judgment of capability; while the word "will" is a statement of intention.

Four questions/statements were designed to study self-efficacy:

- Can you handle another capstone project of a completely different genre?
- Can you finish a future project completely and on time?
- I feel I can accomplish untaught administration tasks (such as preparing a purchase order and communicating with contractors.)
- I feel I can help others with their capstone projects.

Students were asked to assign a score of between 0 and 100 based on their comfort levels in each of the questions/ statements above.

Sustained Effort

As discussed earlier, students with a strong sense of efficacy generally showed an increased and sustained efforts to be successful (Fratturar, 2018) while students who doubted their ability to accomplish difficult tasks gave up quickly or showed weak commitments to the goals they chose to pursue (Bandura, 1993). Hence apart from the survey, the laboratory booking records were also studied. In order to use the laboratory facilities, students had to book the laboratory facilities prior to usage for better facility management as well as to ensure safety. These records were good indication of the number of hours students spent on the capstone project per week. The total number of hours per week is computed by multiplying the number of students working on capstone projects in the four Chemical Engineering laboratories with the hours they spent in the laboratories.

Results and discussion

Academic Motivation Survey (AMS)

It was found that the adapted AMS subscales were reliable for use with the 2 capstone student cohorts. With reference to Table 1, the Cronbach alpha scores for all the subscales for both the AY2018/2019 cohort and the AY2019/2020 cohort ranged from 0.68 to 0.9.

Table 3: *Types of motivation exhibited by AY2020/2021 students*

	α	Mean	Std Dev	Ranking
IM-TK	0.90	5.67	1.39	3
IM-TA	0.79	4.03	1.02	5
IM-ST	0.90	3.75	1.76	6
EM-ID	0.69	5.71	1.03	**2**
EM-IN	0.71	4.75	1.6	4
EM-ER	0.73	5.83	1.03	**1**
AM	0.68	2.55	1.40	7

Table 4: *Types of motivation exhibited by AY2019/2020 students*

	α	Mean	Std Dev	Ranking
IM-TK	0.80	5.72	1.00	**2**
IM-TA	0.75	5.14	1.34	4
IM-ST	0.84	4.92	1.53	6
EM-ID	0.71	5.88	1.23	**1**
EM-IN	0.73	4.96	1.59	5
EM-ER	0.68	5.57	1.46	**3**
AM	0.85	2.63	1.61	7

From the AMS survey results presented in Tables 3 and 4, several observations can be made.

The top three types of motivation exhibited by both cohorts were the same (EM-ER, EM-ID and IM-TK). DCHE students were generally found to be more extrinsically motivated than intrinsically motivated. This is similar to the results of a study by Lim (2010) on the attitude and motivation of junior college students where they were found to be more extrinsically motivated than intrinsically motivated towards the learning of Mathematics. This is a suitable reference as the students were of the same age group as DCHE students and the Chemical Engineering curriculum is heavy on the applications of mathematics.

The differences in scores between extrinsic motivation and intrinsic motivation for DCHE students were however, small. This is contrary to the findings by many researchers such as Lim (2010) where the scores for extrinsic motivation subscales can be more than double the intrinsic motivation subscales. This indicated that while DCHE students could not ignore the realities of grades and their extrinsic power, their interest in learning did not diminish. This observation is further supported by the high IM-TK scores for both cohorts.

Table 5: *Top 3 types of motivation for the two cohorts*

Ranking	AY2019/2020	AY2020/2021
1st	EM-ID	EM-ER
2nd	IM-TK	EM-ID
3rd	EM-ER	IM-TK

Looking at Table 5, between the two cohorts, it is noted that for the AY2019/2020 cohort that completed the student-initiated Capstone Project module, the IM-TK score is ranked second highest compared to the AY2020/2021 cohort that has just started the student-initiated Capstone Project module, indicating that student-initiated Capstone Project contributed to higher level of motivation in students. For the extrinsic motivation type, the AY2019/2020 cohort also showed greater autonomy. The score for EM-ID was higher than EM-ER signifying that students were more motivated by the value or importance of the activity than external rewards. This again indicated a shift towards intrinsic motivation. The above two findings suggest that allowing students to ideate and work on capstone projects of their choices and interests do affect the motivation, and in fact results in a shift on the motivation continuum towards more intrinsically motivated.

Self-Efficacy Survey (SES)

The results for each individual statement/question are tabulated in Tables 6 to 9.

Table 6: *Responses to Question 1 by students from both cohorts*

Question /Statement	Quartile	AY2018/2019 Cohort		AY2019/2020 Cohort	
		Number	Mean Score	Number	Mean Score
Can you handle another capstone project of a completely different genre?	0-25	2	20.5	0	0
	26-50	4	38.2	5	44.4
	51-75	7	57.3	9	58.7
	76-100	4	82.9	5	87.5

Table 7: *Responses to Question 2 by students from both cohorts*

Question /Statement	Quartile	AY2018/2019 Cohort		AY2019/2020 Cohort	
		Number	Mean Score	Number	Mean Score
Can you finish future project completely and on time?	0-25	2	18.0	0	0
	26-50	3	40.3	4	23.0
	51-75	8	61.3	7	63.3
	76-100	4	72.6	8	86.2

Table 8 *Responses to Statement 3 by students from both cohorts*

Question /Statement	Quartile	AY2018/2019 Cohort		AY2019/2020 Cohort	
		Number	Mean Score	Numb er	Mean Score
I feel I can accomplish untaught administration tasks.	0-25	2	17.5	0	0
	26-50	2	38.3	1	33
	51-75	5	59.8	8	67.2
	76-100	8	82.5	10	90.4

Table 9: *Responses to Statement 4 by students from both cohorts*

Question /Statement	Quartile	AY2018/2019 Cohort		AY2019/2020 Cohort	
		Number	Mean Score	Numb er	Mean Score
I feel I can help others with their capstone projects.	0-25	2	19.2	0	0
	26-50	2	3.4	4	44.7
	51-75	6	72.1	8	69.2
	76-100	7	88.6	7	89.1

From the four tables, it can be observed that there is an increase in the number of students assigning scores in the third and fourth quartiles for the AY2019/2020 cohort than students from the AY2018/2019 cohort. This shows consistently that self-efficacy (SE) increased when students were allowed to carry out experimentation on topics that they crafted. This observation is summarized in Table 10 by adding the number of students giving scores in the third and fourth quartiles together.

Table 10: *Students scoring 51% to 100% to each Question / Statement for both cohorts*

Question/ Statement	Ay2018/2019 (Old)		AY2019/2020 (New)	
	Number	%	Numbe r	%
1	11	64.7	14	73.7
2	12	70.6	15	78.9
3	13	76.5	18	94.7
4	13	76.5	15	78.9

Referring to Table 8, the increase in self-efficacy was particularly obvious. 94.7% of the students from the AY2019/2020 cohort, answered in the 51-100 range, while only 76.5% of the AY2018/2019 class answered in the same range on the statement. “I feel I can accomplish untaught administration tasks (such as preparing a purchase order and communicating with contractors)”.

Sustained Effort

With reference to Table 11, the AY2019/2018 cohort spent slightly more time on their Capstone Project. The difference is however insignificant based on 95% confidence level and in a way contradicts the findings from self-efficacy study. One possible explanation on why there is no significant increased level of commitment could be due to the fact that some students were doing their capstone projects at home instead of at the laboratories. For example, there was a group of students working on prolonging the burning time of candles used for religious purposes. This group of students did the entire project in a student member’s home as Singapore Polytechnic has a “No naked flame” policy. Another possible reason is the large variation in the data resulting in a very large standard deviation. The number of hours spent in the first few weeks were low as most purchases required for the capstone projects had not arrived. The numbers then ramped up and peaked towards the end of the semester. Week 6 however is atypical as it was before the Mid-semester test week and hence most students would choose to revise for the test rather then work on the captstone project. The numbers plunged drastically. A different method to capture the students’ actual commitment must hence be designed.

Table 11: *Average hours* spent on Capstone per week*

Week	AY2018/2019	AY2019/2020
1	35	56
2	43	68
3	42	Not Available
4	52	56
5	80	78
6	12	8
7	44	30
8	32	44
9	84	Not available
10	88	90
11	82	86
12	86	82
13	66	66
Mean	57.38	60.36
Std Dev	25.02	25.25
t-value		-0.28942
p-value		0.77497

**Hours is computed by multiply the number of students by the number hours they spent in the lab.*

Conclusion

This study sought to answer the question of whether intrinsic motivation and self-efficacy can be increased through curriculum design, more specifically, by allowing students to ideate and work on their own ideas for the capstone project.

The results indicate that DCHE students' intrinsic motivation can be enhanced by creating opportunities for students to have control over their learning, creating meaningful connections between the students and the research topics and increasing students' perceived competence in completing tasks.

While the efforts to design curriculums and/or develop a learning environment conducive for more autonomous types of motivation can be immense, the benefits are sufficiently crucial. Efforts to boost more intrinsic forms of motivation should be encouraged and supported in order to increase students' intrinsic motivation and self-efficacy to explore, participate, reach true knowledge gain and nurture new innovative thoughts for greater success.

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A PRACTICE OF DEEP LEARNING BY GEOMETRY

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Abstract

In this paper, we introduce three activities carried out with the senior students in the 4th grade: supplementary lessons for the first-grade students, open courses for junior high school students and their own research presentation. The purpose of these activities is for the senior students to gain the ability to understand some mathematical concepts deeply and explain them clearly. Moreover, we hope that they make use of these experiences in their research and presentations.

The open courses have been held at Kurume College since 2010, in which the authors gave introductions to "curvature" and "quadratic curves" with the help of senior students. According to the questionnaire sent out after the open courses, the participants gave us a high evaluation.

In geometry of modern mathematics, the curvature is one of the essential tools to analyze curves and surfaces. Intuitively, we know how much bent a curve is by computing its curvature. In addition, the idea of curvature is applicable to various fields, such as mechanical engineering, electrical and electronic engineering, control and information engineering, and materials systems engineering.

It is well known that quadratic curves appear in cutting the surface of a cone by a plane. Changing the cutting angle, we have three types of quadratic curves: namely, parabolas, ellipses, and hyperbolas. The second named author made a nice teaching material, which is a plotting sheet to draw quadratic curves.

Based on the experience at the open courses, the senior students proceeded to study the curvature that appeared in several engineering fields at the classes of group learning at Kurume College and gave successful presentations at the engineering education symposium in 2020. It is possible to regard these three activities as a series of active learning. In this paper, we take up the open courses among our three activities and describe them and their results precisely from the point of view of active learning.

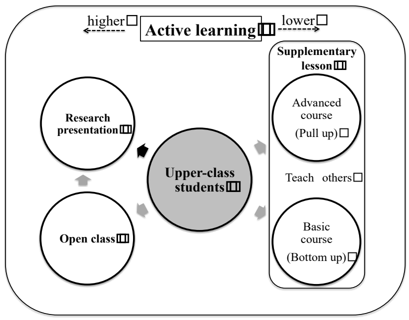
Keywords: *Mathematics education, Open courses, Quadratic curve, Curvature, Active learning*

Introduction

The notion of active learning is introduced by Collins (2003) as "The process of having students engage in some activity that forces them to reflect upon ideas and how they are using those ideas. Requiring students to regularly assess their own level of understanding and skill at handling concepts or problems in a particular discipline. The attainment of knowledge by participating or contributing. The process keeps students mentally, and often physically, active in their learning through activities that involve them in gathering information, thinking, and problem solving".

The main purpose of this work is to help our students acquire the skills of learning by themselves, unifying knowledge, and giving a presentation in the class. Moreover, we had senior students in the 4th grade help us in *low-level* active learning: supplementary lessons and open classes so that they can connect this experience to their research and presentation (Figure 1).

This article is organized in what follows: Section 2 describes the construction of open courses. In Section 3, we review the scenes of open course with some photos. In Section 4, we introduce an open course about quadratic curves. In Section 5, we introduce an open course about curvature. In Section 6, we describe the result of the questionnaire obtained from the participants. Finally, Section 7 presents our conclusion of this effort and the future challenges.



[Figure 1: Active learning]

§2. The structure of open course

We constructed the open course as follows.

(a) Learning contents
Quadratic curve and curvature.

(b) Construction
- Participants
19 junior high school students (the first to the third grade).

- Leaders
Three teachers and three teaching assistants.

- Time
210 minutes which consists of 60 minutes for quadratic curve and 60 minutes + 90 minutes for preparation and curvature.

§3. Some scenes of open course

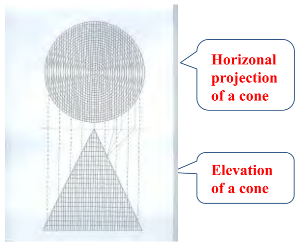
In this section, we review the scenes of the open course with some photos. The teachers write some points on the blackboard to solve the problems or show slides on the screen (Figure 2). The participants write the points on their answer sheets before solving problems. At the same time, the teaching assistants walk around the participants to answer their questions (Figure 3). Through these activities, the teaching assistants developed their ability to teach mathematical subjects.

[Figure 2: Lecture]

[Figure 3: question answering by teaching assistant]

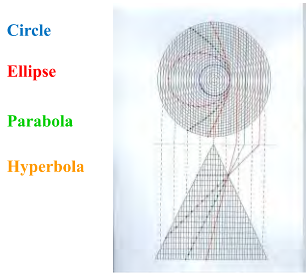
§4. Quadratic curve

A quadratic curve is in general defined to be zeros of polynomials of degree 2 in two variables. It is well known that each quadratic curve is divided into four types, that is, a hyperbola, a parabola, an ellipse or a circle. In the open courses, we introduce a quadratic curve by showing a section appearing in cutting a cone.



[Figure 4: Chart form of a cone]

Changing the cutting angle, we obtain all four kinds of quadratic curves mentioned above (see Figure 5).



[Figure 5: Quadratic curve obtained from the angle of cutting]

§5. Curvature

Curvature is any of several strongly related concepts in geometry. Intuitively, the curvature is the amount by which a curve deviates from being a straight line, or a surface deviates from being a plane. For curves, the canonical example is that of a circle, which has a curvature equal to the reciprocal of its radius. Smaller circles bend more sharply and hence have a higher curvature. The curvature at a point of a differentiable curve is the curvature of its osculating circle, that is the circle that best approximates the curve near this point. The curvature of a straight line is zero. The curvature of a curve at a point is normally a scalar quantity, that is, it is expressed by a single real number.

Before the introduction of curvature, we explained the definition of limits and differential giving some examples of them (Figure 6). After that, we gave the following exercises to the participants to let them understand them more deeply.

Exercise 1. Calculate the following for function $f(x) = 3x + 2$, where a is a constant.

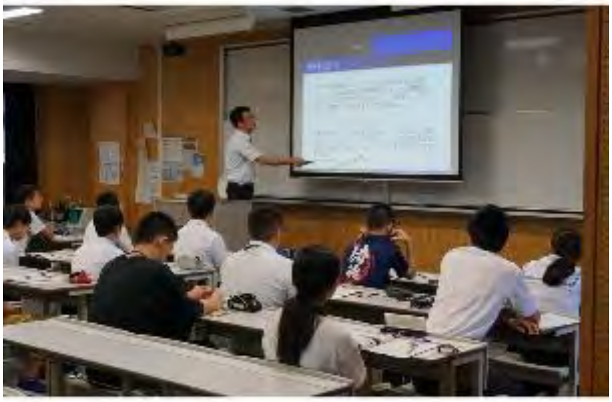
(1) $f(1), f(a)$ and $f(a+h)$
(2) $\lim_{h \to 0} \frac{f(1+h)-f(1)}{h}$, $\lim_{h \to 0} \frac{f(a+h)-f(a)}{h}$
(3) $f'(x)$

Exercise 2. Calculate the following for function $f(x) = 3x^2 + 2$, where a is a constant.

(1) $f(1), f(a)$ *and* $f(a+h)$
(2) $\lim_{h\to 0}\frac{f(1+h)-f(1)}{h}$, $\lim_{h\to 0}\frac{f(a+h)-f(a)}{h}$
(3) $f'(x)$

Exercise 3. Calculate the following for function $f(x) = \frac{1}{x}$, where a is a constant.

(1) $f(1), f(a)$ *and* $f(a+h)$
(2) $\lim_{h\to 0}\frac{f(1+h)-f(1)}{h}$, $\lim_{h\to 0}\frac{f(a+h)-f(a)}{h}$
(3) $f'(x)$



[Figure 6: Explanation of function]

After the participants tried exercises concerning differential, we introduced the definition of curvature with some examples (Figure 7).

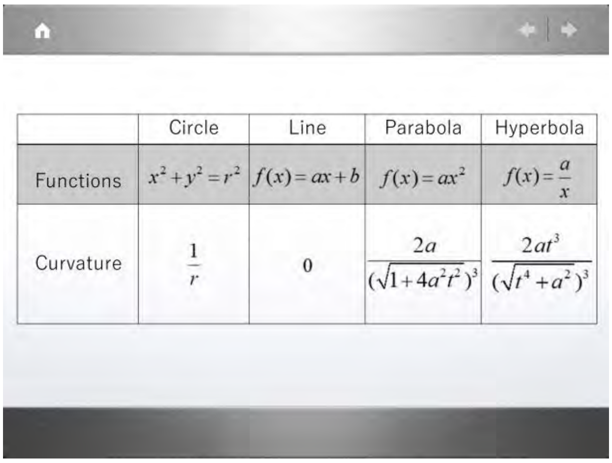
[Figure 7: Explanation of curvature for parabola]

Next, we gave the following exercise to the participants to be able to calculate curvature for some functions.

Exercise 4. Calculate the curvature for the following functions.

(1) $f(x) = 3x + 2$
(2) $f(x) = 3x^2 + 2$
(3) $f(x) = \frac{1}{x}$

Finally, we introduced curvature for the following functions that are generalized from exercise 4.



	Circle	Line	Parabola	Hyperbola
Functions	$x^2+y^2=r^2$	$f(x)=ax+b$	$f(x)=ax^2$	$f(x)=\frac{a}{x}$
Curvature	$\frac{1}{r}$	0	$\frac{2a}{(\sqrt{1+4a^2t^2})^3}$	$\frac{2at^3}{(\sqrt{t^4+a^2})^3}$

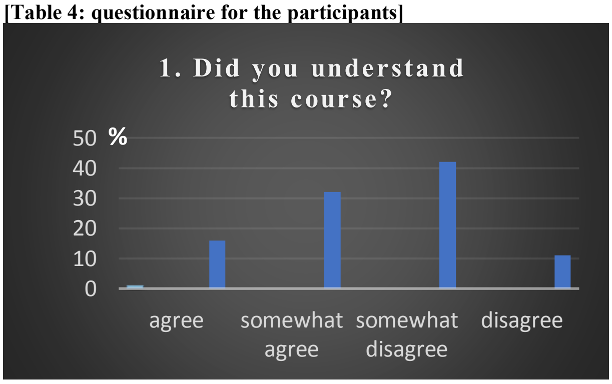
[Figure 8: Curvature for some functions]

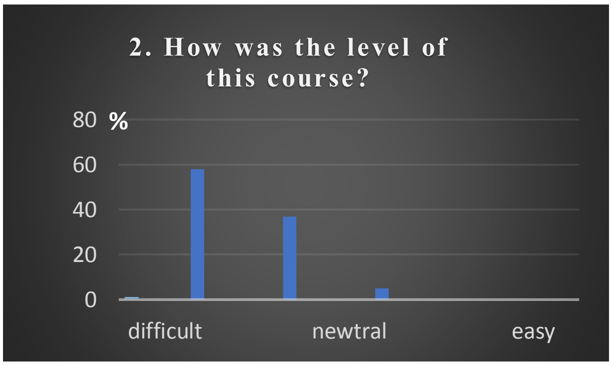
§6. Results of the questionnaire

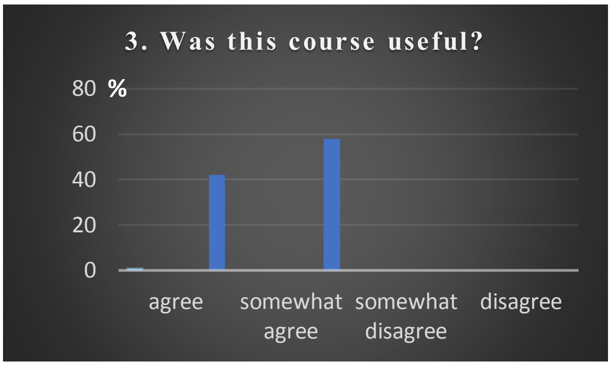
We have taken the questionnaire for the participants concerning the above themes. The items of questions and their results are the following:

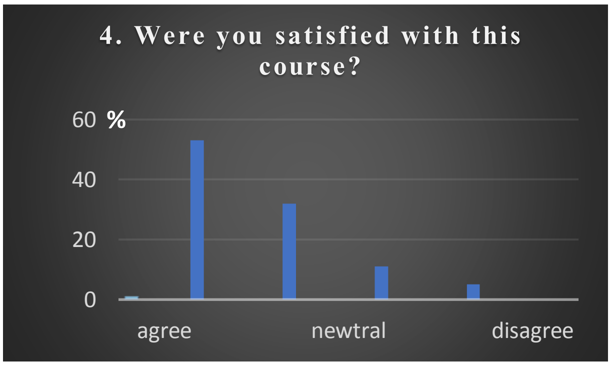
Question 1. Did you understand this course?
Question 2. How was the level of this course?
Question 3. Was this course useful for you?
Question 4. Were you satisfied with this course?

[Table 4: questionnaire for the participants]









Due to the result of Question 1 and 2, the participants understood our lecture despite not having elementary themes. One of the reasons is why the lecture was focused on the way to compute the curvature instead of strictly theoretical argument.

Since a quadratic curve is familiar with the participants in daily life, many of them answered positively Question 3. As is shown in Question 4, more than 80% of the participants were satisfied with the open course.

§7. Conclusion of this effort and a future subject

We had the following comments about our teaching materials from the senior students.

- It was interesting that all quadratic curves appeared in cutting a cone.
- I was able to understand how much the functions were bent using the curvature obtained by differential. So, I want to study the curvature more in the future.

The questionnaire described in section 6 showed beneficial results. Furthermore, from these comments, we consider these themes are valid as teaching materials.

The senior students gave a presentation on these results at a symposium held in 2020. Their presentations got the point and were clear. This means that they had a good grounding in mathematics through this trial including the supplementary lessons and an open class. Therefore, we can conclude that their activities were successful for not only participants but senior students.

Now we introduce two teaching materials that help students' research and presentation in the future in what follows.

One is "*L-S category*" (Cornea, Lupton, Operea & Tanre, 2003; Miyaji & Sakai, 2013) which is an invariant for various figures. We feel easy to begin since we can learn it visually as knot theory and since we need to have little preliminary knowledge on it. For these reasons, this theme would be interesting for students. For example, the L-S category of a torus and a Klein bottle are both two. There is a *fibrewise* version of the L-S category and it is known to have a possibly different value from the ordinary L-S category. As a simple example, a torus has the value two as its ordinary L-S category, but one as its fibrewise version (Cornea, Lupton, Operea & Tanre, 2003). Using the property of the fibrewise A_∞-structure, the third named authors gives that the fibrewise L-S category of the Klein bottle has the value two (Sakai, 2010). In addition, it is known that the fibrewise L-S category is related to "topological complexity", a field of research involved in the motion planning of robot arms (Iwase & Sakai, 2010).

The other is knot theory, which is also a fascinating field in topology. It is easy for beginners to understand it since it is not necessary to know its background well and there are various teaching materials in which they can learn visually (e.g., Kawauchi & Yanagimoto, 2012; Miyaji, Sakai & Nakabo, 2013). On the other hand, knot theory lies in various fields, such as DNA in biology and QFT (quantum field theory) in physics, which correspond to the relevant feature. Therefore knot theory is suitable for students who study the technological fields.

Acknowledgements

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ADOPTING LEARNINGANTS AND EDTECH TOOLS TO SUPPORT HOME-BASED LEARNING DURING COVID-19

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Abstract

In April 2020, Singapore entered into a period of structured social distancing to minimize the risk of a big outbreak of the Coronavirus disease 2019 (Covid-19). As education institutions all moved into full Home-Based Learning (HBL), there was a need to identify suitable online platforms and tools to facilitate teaching and learning, and monitor students' learning progress.

This paper showcases the various ways technology and data were embraced to support teaching and learning in a virtual environment with special focus on LearningANTS, an online system designed by educators for educators and learners by a Singapore tertiary institution. While online learning platforms and tools were essential for facilitating student learning at the onset of HBL, ascertaining students' progress and development were of equal importance to many educators. LearningANTS harnessed the power of learning analytics to support differentiated learning. Learning patterns, habits and performance were tracked digitally as students attempted online tutorials deployed by the system. LearningANTS then leveraged the data captured and presented the students' progress and performance findings through various easy-to-read charts on the educator's dashboard. From the dashboard, educators could monitor performance of the individual student as well as the whole class, both remotely and in real time. Educators could also create collaboration quizzes to facilitate cooperative learning in the virtual environment with the in-built features of LearningANTS. At the same time, students themselves were able to monitor their own learning progress in the student-facing system.

This paper will also feature other EdTech tools employed to enhance the learning experience during Covid-19, highlighting the strengths and pain points experienced during lesson development and delivery. Despite the challenges faced, the learning outcomes of students and responses from educators were generally encouraging. These shared approaches and strategies, though geared towards the learning of Mathematics in particular, are nevertheless applicable to the teaching of tertiary students in general.

Key words: Home-Based Learning, Technology, Data, LearningANTS, Differentiated Learning, Cooperative Learning, Mathematics

Introduction

In April 2020, Singapore entered a period of structured social distancing, also known as Circuit Breaker in order to pre-empt escalating Covid-19 infections. In response to this implementation, Institutes of Higher Learning moved into full Home-Based Learning (HBL).

As teaching staff members at Singapore Polytechnic (SP) scurried to prepare for HBL for the very unusual semester, several key thoughts came into our minds. Firstly, it was essential for both students and lecturers to track learning progress in the virtual environment, and this could be facilitated using learning analytics. Secondly, since face-to-face classroom teaching was no longer an option, there was an urgency to identify suitable platforms to conduct synchronous "live" lessons with our students. Thirdly, we would need to develop or curate relevant lecture videos to support asynchronous learning. Experiences in addressing these three specific areas and the adoption of EdTech tools will be shared. The effectiveness and limitations of EdTech tools will also be higlighted, and recommendations suggested for future deployment.

Adopting Learning Analytics to Track Learning Progress

The data for the adoption of LearningANTS are based on two classes of Engineering Mathematics II (EM II) conducted in Academic Year 2020/2021 Semester 1 which started in April 2020 at SP. This is a second-year module conducted in flipped learning mode and the module has a high focus on Calculus, designed to provide the relevant mathematical knowledge and skills for Engineering students. The essence of the flipped classroom pedagogical model is a reconsideration of when to provide support to students when they need it most (Te@.chthought, 2014). For EM II, lecture videos were already in place to support flipped learning. In an effort to provide more opportunities for the 700 students reading EM II to hone their mathematical skills through online tutorials, and for lecturers to better track students' learning progress during Covid-19, the module coordinator of EM II adopted LearningANTS.

LearningANTS, which stands for Learning Analytics Networked Tutoring System, is an online system that harnesses the power of learning analytics to facilitate differentiated learning. As stated in The Horizon Report (Johnson et. al., 2012), "Learning analytics refers to the interpretation of a wide range of data produced by and gathered on behalf of students in order to assess academic progress, predict future performance, and spot potential issues". This system was co-developed by SP and an industry partner. It had been deployed in various other modules previously, but this was the first implementation for EM II.

At the start of the semester, the module coordinator of EM II first setup a module road map in LearningANTS. The scheduled topics were then released adaptively according to the module road map. In LearningANTS, online tutorial questions are categorized into four different levels based on their degrees of difficulty, namely Beginner, Advanced Beginner, Competent and Expert levels. Students then progressed through these four difficulty levels until they reached the target level set for EM II, which in this case was the Advanced Beginner level. The difficulty level of each question was displayed on the students' screen and students could also view the online solutions after they had submitted their answers. Should they have any problems understanding the solution, students could submit an online enquiry via the 'Feedback to Lecturer' feature on the dashboard. See Figure 1 for the student-facing system in LearningANTS.

Figure 1. Student dashboard – deployment of questions to students.

Students who were weaker in Calculus could progress at a slower pace and the system would then suggest diagnostic topics to help address their specific needs. For example, students who had difficulties with the EM II topic 'Integration of Rational Functions' would be directed to relearn the more foundational topics that were taught during their first year of studies at SP. Figure 2 contains a snapshot of the student dashboard, showing the diagnostic feature in LearningANTS.

Figure 2. Student dashboard – diagnosis of students' learning needs.

On the other hand, students who were more academically inclined could progress beyond the target performance level to stretch their abilities. LearningANTS facilitated differentiated learning where students were given different pathways to learn in terms of content or process. For process, it refers to the activities the students were to work on in order to understand the contents they were learning (Tomlinson & Imbeau, 2010).

Students could also monitor their own progress in LearningANTS. For example, by clicking on the 'Progress' tab on the dashboard, they could see the number of questions attempted for each topic and also review those questions they had answered incorrectly, see Figures 3 and 4. These features in LearningANTS support the development of self-directed learners as described by Gibbons (2002), "… the spectrum of self-directed learning can begin with teacher-directed learning with the responsibility gradually shifting to the learners."

Figure 3. Student dashboard - display of Attempts Statistics.

Figure 4. Student dashboard - display of correctly/incorrectly answered questions by students.

During the HBL semester, as lecturers were unable to see students face-to-face, it became even more crucial to track students' learning progress online. In LearningANTS, student data were captured and displayed on various reporting charts in the lecturer-facing system. This paper will highlight three specific reporting charts in LearningANTS that enabled a lecturer to monitor class performance, track progress of individual student, and identify questions most students had difficulties answering.

Firstly, the ‘Topic Achievement’ chart shown in Figure 5 presents class performance by topic. The levels of achievement are color-coded for easy visualization. For example, by looking at the first yellow bar displayed on the chart, a lecturer gets the summary of 14 students having achieved Advanced Beginner-level while 3 others had gone beyond the target level for the topic on ‘Basic Integration’.

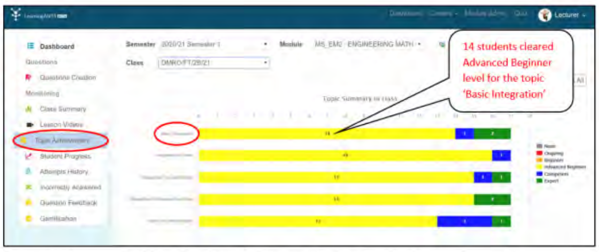

Figure 5. Lecturer dashboard – ‘Topic Achievement’ chart tracks class performance.

Secondly, from the ‘Student Progress’ chart shown in Figure 6, one could determine the number of questions each student attempted and the level achieved, by topic. For example, for the topic ‘Integration by Parts’, Student B had attempted 35 questions and had gone beyond the target level set by the lecturer to reach Competent level. The same reporting chart also provides information on attempts made to acheive the target level by different students in the class. For example, Student E had to do three times the number of questions attempted by Student G in order to clear the target level. This information is helpful to inform the lecturer students who needed more help than others in the entire class.

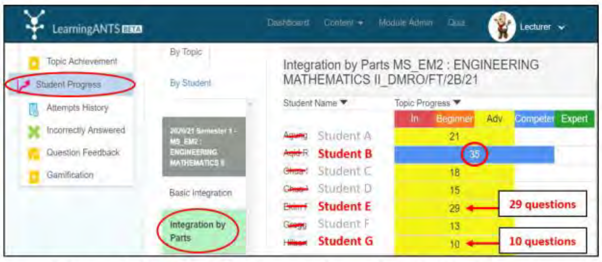

Figure 6. Lecturer dashboard – ‘Student Progress’ chart tracks individual student performance.

Thirdly, from the ‘Incorrectly Answered’ chart shown in Figure 7, one could identify the Top 10 questions that students had difficulties answering. This useful piece of information enabled the lecturer to identify and address common problems faced by students in the class. The lecturer could then address those questions collectively during the synchronous online lessons conducted through Microsoft Teams.

Figure 7. Lecturer dashboard – ‘Incorrectly Answered’ chart displays the Top 10 questions.

Cooperative Learning through LearningANTS

In LearningANTS, the lecturer could also create collaboration quizzes to facilitate cooperative learning in the virtual environment. Cooperative Learning involved students working together to achieve common goals or complete group tasks (Gillies, 2016). The aim was to observe how students collaborate and learn in a team setting where the identities of their team members were kept anonymous. As students had been using LearningANTS during the semester, their performance findings had already been captured in the system. Hence, lecturer was able to set up the teams easily, as shown in Figure 8.

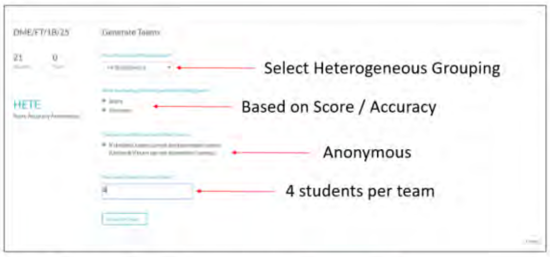

Figure 8. Setting up the collaboration quizzes in LearningANTS.

For this experimentation, heterogeneous grouping was chosen where students of all performance levels were represented in each group. The other type of grouping available in the system was homogeneous grouping where students of similar performance level were grouped together. As the ‘Anonymous’ option was selected for this group of students, they were unaware of the identities of their team members. During the team quiz, students could discuss questions virtually via a chat box in the system. They then voted for the correct answer to each question that was selected from the existing question pool in LearningANTS. See Figures 9 and 10 for screenshots of students in action.

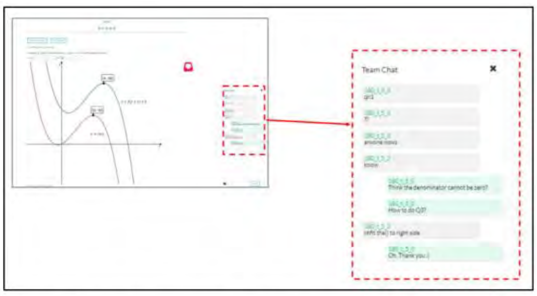

Figure 9. Students discussing the questions via chat box in LearningANTS.

Figure 10. Students voted for the correct answer in LearningANTS.

The lecturer could monitor students' performance in the quizzes via the lecturer dashboard as shown in Figure 11. The results indicated that group performance was higher than individual performance. Students' discussion with their team members helped them clarify their doubts on the mathematical concepts tested and answer the questions correctly. Most students found cooperative learning beneficial to their understanding of the subject matter. One student commented that "It is an interactive way of learning. Not knowing each other was a good thing as I could ask simple questions without feeling embarrassed. Explaining the answers virtually via the chat box was challenging, but in the end it could be done." Moving forward, the effects of cooperative learning via LearningANTS can be explored using different types of groupings i.e. heterogeneous versus homogenous, and different types of identity scenarios i.e. anonymous versus non-anonymous.

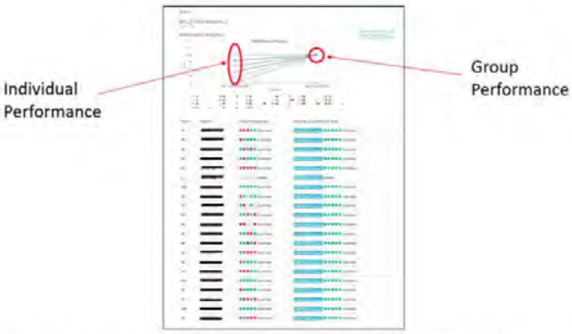

Figure 11. Lecturers monitoring quiz results in LearningANTS.

Setting the Stage for Online Synchronous Lessons

During Covid-19, lecturers explored various options to conduct synchronous lessons online. One EdTech tool recommended was Microsoft Teams (MS Teams) that can facilitate synchronous video conferencing and teaching. After creating the various classes in MS Teams, lecturers were able to call up their students to attend the "live" synchronous lessons simply by clicking on the 'Meet Now' button on the dashboard. This was synonymous with students sitting outside the physical classroom on campus, waiting for the lecturer to tap the staff card to open the door during pre-Covid-19 days. Once the virtual door was opened, the lecturer could then look at the 'Participation' list on the side bar of the dashboard to identify students who were already in. Most of the students would turn up for lessons on time if the lecturer had laid down the ground rules earlier. At the start of each online lecture, the lecturer would state the lesson plan and learning objectives clearly. This way, students were aware of the extent of content coverage as well as pages in the digital course notes they should refer to during lesson. The lecturer would then use the 'Share' feature in MS Teams to broadcast pre-prepared notes to students as the "live" synchronous lectures were conducted remotely from the lecturer's laptop, tablet or iPad. As students were only required to view the lecturer's writing on the notes and listen attentively to the explanation, they were instructed to switch off their audio devices so that they could focus on the online lesson and would not be distracted by the ambient sounds coming out from their microphones. When the learning environment is positive and predictable, implementing classroom level behavior support becomes easier and practices are more likely to be sustained (Sugai & Horner, 2006). See Figure 12 for a screenshot of a video recording of a synchronous lecture.

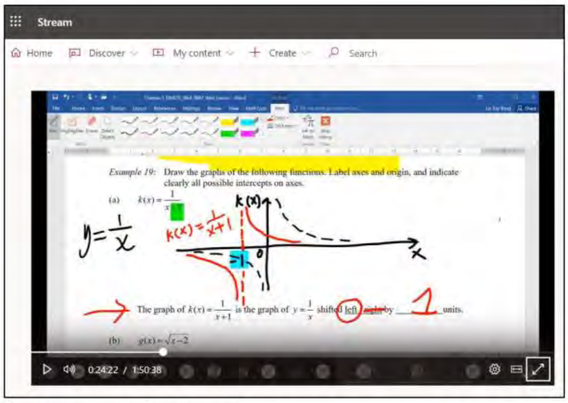

Figure 12. Screenshot of a lecture video (synchronous lesson) uploaded to Microsoft Stream.

Since lecturers did not get to see their students face-to-face, they had to pause their lecture from time to time to check if the students were still present and following the online lesson. To do that, the lecturer would randomly pick one or two students to answer questions online. This seemed to keep students on their toes. Occasionally, the lecturer would appoint students to share their screens, one at a time, to demonstrate how to solve a simple mathematical problem. This provided an active learning environment where class participation was encouraged. 'Active Learning' is, in short, anything that students do in a classroom other than merely passively listening to an instructor's lecture. This includes everything from listening practices which help the students to absorb what they hear, to short writing exercises in which students react to lecture material, to complex group exercises in which students apply course material to "real life" situations and/or to new problems (Paulson & Faust, 1999).

Towards the end of a "live" lesson, the lecturer could pose a digital pop quiz to identify those mathematical concepts that most students were facing difficulties with and clarify them in a timely fashion. Figure 13 shows the responses received from a 5-question pop quiz that was created using Microsoft Forms and deployed via MS Teams. Microsoft Forms is a simple app that creates surveys, quizzes and polls. From the displayed charts generated in Microsoft Forms, it was observed that most of the students in that class were facing difficulties in Q4 as only 12% of the class managed to answer that question correctly. The lecturer would then spend some time to go through that particular mathematical concept with the class, hence addressing the learning outcome that was not achieved earlier during the "live" lecture. By clicking on the 'Open in Excel' icon on the dashboard, the lecturer could also download a spreadsheet that would provide detailed breakdown of students' attempts by question.

Figure 13. Students' performance in pop quiz (formative assessment) via Microsoft Forms.

Another way to monitor students' understanding of my synchronous lessons was to ask the students to submit hand-written homework assignments after class. This could be done electronically via the 'Assignment' feature within MS Teams. To expedite marking of the submitted assignments, students were instructed to take photos of their hand-written solutions, paste the photos into a single Microsoft Word document and 'Turn In' their work in MS Teams before a specified deadline. The lecturer would then open that document, annotate their comments and return the commented copies to the students. As these documents would be uploaded to the cloud, summative marks were not indicated in the returned copies to students. Nevertheless, with qualitative feedback, the lecturer was able to help students take note of their mistakes and also affirm those who had answered the questions well. Figure 14 is a sample of student's work, with feedback given by lecturer to affirm her for the well written solutions.

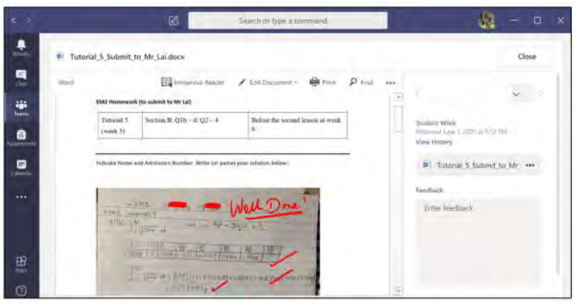

Figure 14. Lecturer's comments on student's homework assignment via MS Teams.

Develop Lecture Videos to Support Asynchronous Learning

HBL for modules which were yet to have online videos such as Basic Mathematics (BM), a module offered to first-year Engineering students who do not have strong foundation in mathematics, and hence lessons have traditionally been conducted in the standard face-to-face classroom teaching mode; the module coordinators were tasked to either curate lecture videos or develop fresh ones using an EdTech tool called Camtasia.

With Camtasia, lecturers could design and record new lecture videos for those topics in BM that did not have suitable digital resources. The videos were created using pre-prepared Microsoft PowerPoint slides that closely matched the materials in students' course notes. As students taking this module were generally not very strong in the subject matter, the recorded videos had to be customized to provide more detailed explanation of the mathematical concepts. Camtasia also had built-in features that enabled lecturers to insert short pop-up quizzes within each video so that students could perform a self-check on their understanding of content learnt at appropriate juncture of the video lesson. Once the lecture videos were finalized, they were uploaded and released adaptively to the 1000 first-year students reading this module. Students could either view these lecture videos as pre-class activities or revisit them to enhance what they had learnt during their synchronous lessons. See Figure 15 for a screenshot of a lecture video that was developed using Camtasia.

Figure 15. Screenshot of a lecture video developed using Camtasia.

Although the task to develop these lecture videos was laborious and time consuming, the positive impact the videos could have on students' learning, especially during Covid-19, could be substantial. As such, a conscious effort was made to gather students' feedback informally, early in the semester. That would then allow lecturers to improve on the quality of their subsequent videos to make asynchronous learning more effective for students. The comments received were generally favorable. Most students were able to understand the contents after viewing the videos, although some may need to re-watch the videos to fully capture the essence. Moving forward, more lecture videos would be recorded to support asynchronous learning. These videos could then be redeployed in the future to facilitate flipped learning for BM.

Feedback from Students

LearningANTS makes students' performance and progress in learning visible without needing the lecturers to conduct separate formative assessment for feedback on students learning. In order to check if the positve observations matched students' learning experience, students were asked to share their experiences about HBL. The experiences were generally positive. These were some of the comments received from students.

“The live sessions with the lecturer were beneficial. And to test whether I understand, we were provided with the LearningANTS platform to test ourselves which is effective also.”

“The use of LearningANTS along with quizzes and tutorials allowed me to have more practice and test my understanding.”

“Able to and also encouraged to raise questions and doubts as and when, making it another good experience for Home-Based Learning!”

“It's quite okay for me but is very easy to get distracted at home.“

It was certainly gratifying to know that the lecturers' efforts in enhancing the learning process during HBL were appreciated by students.

Conclusion

This paper shared how one can make use of educational technology to teach and monitor students' learning progress. So far, feedback received from students had been quite positive and encouraging. Firstly, in LearningANTS, students were able to attempt online tutorials on their own, at their own pace, and with minimal supervison from their lecturers. They could also monitor their own progress via the system. At the same time, using the various reporting features in the dashboard, lecturers were able to track and monitor the learning progress of the class as well as that of individual student in real time. Lecturers could also conduct team-based activity in the virtual envronment using the quiz feature in LearningANTS to facilitate cooperative learning. Secondly, as students take modules across different academic schools each semester, adopting a common platform like MS Teams to conduct synchronous online lessons had enabled them to adapt to HBL more easily. Thirdly, developing online teaching materials require time and effort. Hence, it may be wise for lecturers to pool our common resources together to share and reduce our workload.

Covid-19 has shown us that humans can innovate and leverage existing technologies for survival. Beyond this pandemic, the way our students learn will change. The great South African leader Nelson Mandela once said “Education is the most powerful weapon which you can use to change the world.” As we embrace the new normal, educators will have to explore alternative and creative ways to teach our learners. Proper training in the pedagogies and learning analytics must be provided to equip lecturers with the necessary knowledge and skills to better handle the challenges and tasks ahead.

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LARGE SCALE E-PROCTORED ASSESSMENT FOR HOME-BASED LEARNING

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Abstract

When campus closure took effect in April 2020 due to a nation-wide lockdown brought about by the COVID-19 pandemic situation, it necessitated a change to full home-based learning (HBL). This was both a challenge, as well as a chance for innovative transformation of the online assessment, carried out by the School of Electrical & Electronic Engineering (SEEE) of Singapore Polytechnic (SP), Singapore. Past yearly HBL conducted since the earlier severe acute respiratory syndrome (SARs) pandemic in 2003, had seldom included formal online assessment, with strict requirements, similar to that of physical in-person assessment or examination. SEEE undertook a school-wide implementation of remote e-proctored online assessment involving more than 100 staff, 2500 Pre-Employment Training (PET) and 500 Continuing Education and Training (CET) students, for over 100 modules, in what was possibly a first implemented on such large-scale for the institution. Innovative re-thinking of the usual assessment procedures and processes, including ensuring that staff and students were prepared for a new assessment experience, set e-proctored assessment into motion and all the preparations were done with almost all staff and students under work-from-home (WFH) situation.

This paper shares the considerations, preparations and guidelines put together to support the staff and students for e-proctored online assessment. Ways to scaffold student experience in working and uploading solutions online for assessment purposes were also implemented prior to the actual experience to ensure the new processes did not impede their progress when completing the e-proctored assessment. Challenges in implementation and ways to address the challenges for large group online assessment proctoring will also be shared. Findings from questions included on online assessment proctoring in a survey on HBL experience suggested that students concurred that the preparation for assessment and the assessment itself helped them to be engaged, and better gauge their progress in learning during HBL. With the experience garnered, it provided SEEE with useful learning to improve and fine-tune any future such implementation, an undertaking never previously attempted in SP.

Keywords: *e-proctoring, home-based learning,online assessments, pandemic, student engagement,*

Introduction

The School of Electrical and Electronic Engineering (SEEE) of Singapore Polytechnic (SP) offers four diploma programmes which are delivered through lectures, tutorials and lab practicals, conducted on campus. This approach was up-ended when Singapore experienced an unprecedented lockdown in April 2020, due to the COVID-19 pandemic, similar to other occurrences in countries around the world. With the campus grounds kept off-limits to almost all staff and students, SEEE had to undertake full home-based learning. The changes needed were as follows:

- Suspension of all in-person lectures and these were replaced by asynchronous learning contents made available through the learning management system (LMS), Blackboard. The asynchronous online contents should minimally be narrated PowerPoint videos, and in a series of mini-lectures to facilitate student learning.
- Tutorials and practicals were conducted online synchronously through platforms such as Skype for Business or MS TEAMs, which were the approved platforms for teaching and learning purposes.
- Lab demo videos to replace suspended in-person lab sessions.

Given the sudden imposition of the lockdown and the unpredictable duration, the School had to be prepared for the long haul or the worst-case scenario. Both the teaching staff and students faced the challenge of starting a new academic semester in a totally unfamiliar situation of a fully online teaching and learning environment, and with almost all parties required to work and learn from home.

In the acute situation where changes were made to address the full HBL implementation, it was imperative that there were consistent implementation across the board especially on the expected teaching and learning practices, particularly so for a large school such as SEEE. That ensured students could be better eased into the new learning environment. New standard operating procedures (SOPs) for the conduct of synchronous online lessons were outlined so that teaching staff and students were fully aware of the School's expectations, as applied across all the modules offered. Example of SOP included requiring students to upload their own weekly tutorial submissions to the LMS under Group Discussion Board, or other lecturer-prescribed channels, so that teaching staff could monitor how the students were coping and learning under the changed learning environment brought about by campus closure.

Due to this requirement, teaching staff who previously used the LMS mostly for accessing learning resources and students' quizzes attempts, had to learnt how to view student tutorial submissions and download them from the LMS; guide their students on where to upload the images of their hand-written solutions to the LMS. This requirement paved the way for a similar requirement when the e-proctored assessment was eventually implemented.

Assessment cannot be separated from the teaching and learning activities. It is integral in ensuring the quality of the curriculum design and delivery, that there be constructive alignment between learning outcomes, teaching and learning activities and the assessment activities.

To have an indication of how well students were coping in the new teaching and learning environment, there was a need to have some form of assessment. This would enable timely changes to be made, be these related to the asynchronous learning materials, or the facilitation approaches in the conduct of the synchronous online lessons, and possibly also the students own learning approaches.

At the School-level, the overall student performance and achievement during the semester would provide a measure of future success of the cohort to progress further in their studies and for eventual graduation. This also would help inform decisions on the changes needed, or further improvements for the School curriculum delivery.

The sudden imposition of full HBL mandated changes to the usual traditional teaching and learning approaches, and similarly to the conventional on-campus assessment. Two options were open for consideration: To have the usual on-campus assessment, or alternative assessment (Gordon, 2020), such as projects, report writing and presentations. While the latter option could be suitable perhaps for project-based modules, these did not offer the constructive alignment for the Year 1 and 2 fundamental engineering modules usually delivered through lectures, tutorials and lab practicals.

The School mapped all the possible scenarios, from the best case (business as usual), and regressing towards that of the worst-case (total lockdown). Given the unknown trajectory that the pandemic could take, there could be impact on the three main assessment points: mid-semester tests, practical tests and end-of-semester examination, typically conducted under supervised conditions on campus. Table 1 shows all the possible scenarios.

The School made the decision that as whole, if it could mount assessment for the worst-case scenario, then anything less drastic could be possible. Whatever changes made, whether to assessment or to the curriculum delivery, must be done to ensure the following desired outcomes:

- Academic rigor of the programme
- Student learning progression
- Asynchronous online learning contents were well received and
- Online assessment was secure and with academic integrity.

Table 1 Assessment under different scenarios

Scenario	Mid-semester Test (MST)	Practical test	Semester Exams
Best case	Yes	Yes	Yes
	Yes	Yes	No
	Yes	No	Yes
	Yes	No	No
	No	Yes	Yes
	No	Yes	No
	No	No	Yes
Worst case	No	No	No

The approach chosen was to implement online versions of the usual assessment, consisting of multiple choice questions and unstructured short questions that would assess higher order thinking skills of the disciplinary knowledge for the modules. This could help to provide a measure of the students' continual engagement with their learning and also their progression during HBL. In the event that the lockdown was prolonged, there could be a probable move to award pass/fail instead of the usual academic grades. Should the situation progressed to that state, as whole, the School could make such decisions confidently, based on these online assessment results of the students.

Online Assessment

SEEE devised two forms of online assessments: COVID Formative Assessment (cFA) and COVID Mid-Semester Summative Test (cMST), with the former being small-stakes, fully online assessment, and the latter, the fully online version of the paper-based mid-semester test. The 30-minute-long cFA assessed student learning and performance on the theoretical contents of the topics within the modules. There were four cFA spread across the semester, with two scheduled for the first-half and second-half of the semester each; conducted concurrently for all students taking the same module under supervised conditions. The features of the cFA are as listed in Table 2. While formative assessments typically do not award marks, it was felt necessary to award nominal marks so that students would put in the effort to prepare for the assessment.

The usual in-person paper-based mid-semester test (MST) was conducted in a fully online mode, in the form of cMST. Table 3 compares MST and cMST, and the additional measures taken to address the online nature of cMST, incorporating measures in maintaining academic rigour and integrity. Like MST, the cMST was scheduled during Week 7 of Semester 1, and would contribute towards 20 percent weighting of the overall marks. Additionally, due to the longer duration for the cMST of 1.5 hour, it was implemented in two parts; Part 1 and Part 2. This was in anticipation of any unforeseen major network outage or technical disruption. The partitioning of the cMST into two online submissions also helped to minimise any possible loss of student online submission attempts. A total of 130 CET and PET modules administered cFA, and 102 CET and PET modules administered cMST in May to June 2020.

Table 2 Features of cFA

Marks	Each cFA is awarded 10 marks. Average of best 2 cFA marks out of 4 cFAs and up to 10% total overall marks
Format	1 multiple-choice question (MCQ) and 1 short unstructured question. One question shown at a time
Access to assessment	Requires log in to LMS and upload of image of hand-written solution into LMS and student self-declaration of compliance of original work and non-plagiarism

Table 3 Comparison between MST and cMST features

MST	cMST
Supervised, in-person	E-proctored using Zoom video platform with meeting code and password
Duration 1.5 hour-long with 10 minutes reading time	**Duration** 1.5 hour-long without reading time for online format
Format 10 MCQs and 4 to 5 short questions • Closed book • Formulae list provided	**Format** Part 1* – 15 MCQs Part 2 – 4 short unstructured questions *to be completely uploaded into LMS followed by 10 minutes break before start of Part 2
Distribution of question papers/ Collection of answer booklets by senior invigilator/ invigilator	Use of LMS (Blackboard) requiring log in by student and release of password by invigilator for students to access online assessments which are only available according to the test schedule
No admission to late students 30 minutes after start of test	No admission into Zoom meeting after start of test (no grace period)
Contingency plans: Possible postponement e.g. due to major transport disruption	**Contingency plans:** Possible postponement e.g. due to internet/network outages or disruption.

Key Considerations for the format of the online assessments

For any assessments, academic integrity needed to be uphold as otherwise the results could not genuinely reflect the true performance of the students. Nevertheless, SEEE was cognizant of the fact that whatever measures undertaken could not replicate, and at best, approximate the stringent conditions of physically supervised in-person assessments. Nevertheless, the School endeavored to deter any potential attempts to cheat and dishonesty from taking place (Dyer, Pettyjohn, & Saladin, 2020) (Sun, 2020).

One such measure was that the online assessments were designed to include features such as no backtracking of questions, only one question to be displayed to the student at a time, the order of questions was randomized, and similarly the order of the distractors for each multiple-choice question as well, as recommended (Budhai, 2020) (Weleschuk, Dyjur, & Kelly, 2019). The use of question pool was also implemented where possible to allow for randomization.

Given the conditions under which the assessment were administered, the assessments were also designed to be open book. All questions in the online assessments should be such that the answers could not be readily available through books, notes or even the Internet. This required that students were assessed on higher order thinking skills such as that of analysis and evaluation, beyond simple recall and regurgitation of facts. Students needed to go beyond surface understanding, and to think more deeply to understand the learning contents. Hence the use of unstructured short questions as part of the assessments as these required applications of students' learned knowledge. Typically, this also allows for more than one possible approach, though converging on one correct response, as would normally be found for typical engineering problem solving questions. For the small-stakes online assessments, cFA, these also included one multiple choice requiring students to justify and support their choice of answer by providing written explanation or solution (Ragupathi, Jan 2020) to show their understanding to be awarded full marks.

A further measure was that students were required to provide hand-written solutions with images uploaded to the LMS during the online assessment before they could view and attempt the next question. Although the online assessments could provide for the use of text editor for students to key in their answers, these were rather limited when extensive use of equations, mathematical symbols and formulae formed part of the solutions for most engineering modules. Furthermore, with hand-written solutions, this helped to minimise the likelihood that students could be tempted to cheat through "copy and paste" using the text editor.

The School took a further step to get all students to commit to an honour system through a compulsory student self-declaration. They needed to key in "Yes" answers to all self-declaration statements at the end of the online assessment that served as reminders to students that their online assessment were their own efforts without the help of others.

To prepare students for the two online assessments that SEEE had devised, teaching staff guided students on the format of these two assessments which were also made available on the LMS for students to access (see Figure 1). Students were also to go through the dummy online assessment cMST provided to give them practice and trial runs so that they could familiarise themselves with the format of the online assessment, in particular, the two parts of the cMST, the display of one question and upload of solution before the next question would be displayed, and also the requirement of student self-declaration. This helped to ensure smooth implementation when the online assessments were conducted.

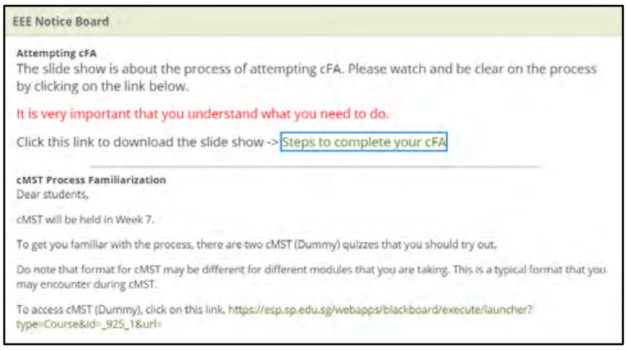

Figure 1 Information on the two online assessments for students for familiarization and trial runs

E-proctoring of Online Assessments and Preparations of Staff and Students

A key step taken was that the online assessments were conducted under supervised conditions through remote e-proctoring. Zoom video conferencing platform was used for the purpose as it allowed an entire class of up to 25 participants to be viewed simultaneously and was available free for up to 40 minutes, thus suitable for the cFA which was 30-minute-long. For the cMST, the School acquired the use of licensed Zoom without limits on time.

Staff were trained on the use of Zoom video conferencing platform for proctoring purpose, as this was not the default platform for the purpose of teaching and learning. For the purpose of conducting a cFA, the whole process flow chart was prepared as shown in Figure 2. It guided the entire procedures administered by the staff who were proctors or invigilators of the online assessments. Teaching staff were trained on how to download class lists of students that included the student photos needed for identification, scheduling Zoom meetings according to the assessment schedule for each module, and emailing these Zoom meetings to the intended students. Students were informed through various communication channels, and were also guided through mock tests so that they could be familiar with these Zoom meeting invites and were able to join such meeting smoothly.

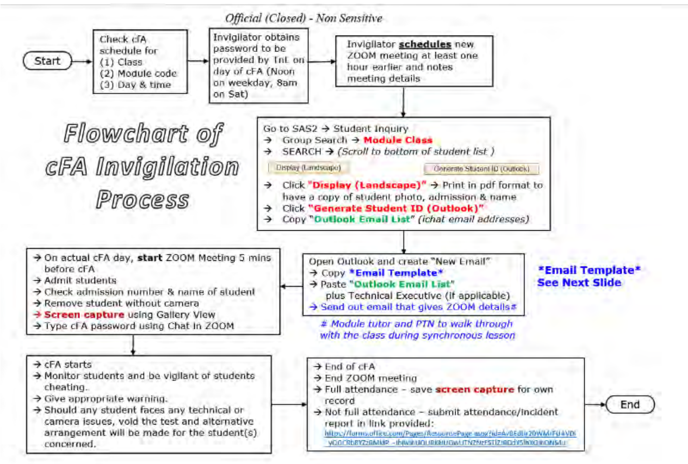

Figure 2 Flowchart for staff on online cFA

Figure 3 shows the typical email template that staff used for the Zoom meeting invites to students. It included a stern reminder to students not to share the meeting invite so that only intended students could be admitted into the Zoom meeting for the purpose of the online assessments.

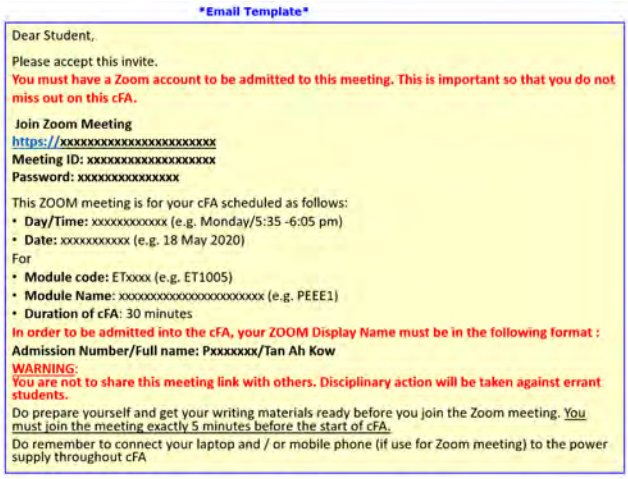

Figure 3 Email template for Zoom meeting invite for online assessment to students

During the online assessments, students were required to display name as the follows: module class, admission number and full name for the purpose of attendance taking; checked against the information found in student information systems prepared by the staff who were invigilating the online assessments. A typical screen capture taken is shown in Figure 4. Given the demands of observing students on the video grid, two staff presided over the online assessments for each class.

Figure 4 Screen capture of students during an online assessment through Zoom

Addressing technical challenges of online assessments

For the online assessments to be implemented, both staff and students had to have laptops with web-cameras and network access. Students also need mobile phones to take images of their solutions for uploading. All the above had to be working well for the smooth conduct of the e-proctored online assessments. The LMS capacity to enable large number of student access was also crucial for whole-school implementation. How these risks were managed and minimized is discussed here.

- Support for devices and network access for students

Early in the semester, all teaching staff were required to check that students were able to access the LMS as there could be students facing challenges of online learning. That was established through the last access date of students for their modules in the LMS. Students who could not even accessed the LMS could be at risk as they would missed out on not just accessing the learning contents, but also important communication related to their learning. Where students could not access the LMS due to lack of necessary network access or devices for HBL, support was extended through loans of laptop, or if necessary, to be in allowed back on campus if they lack Wifi access at home. Early intervention was necessary as this was to ensure students could keep pace with the learning and also able to undertake the online assessments that started from Week 3 of the semester. Through the two rounds of small-stakes cFAs held during weeks 3 and 5, teething issues such as students inability to join Zoom meetings or to upload images of their solutions were resolved to pave the way for the smooth implementation of the online assessment of cMST in Week 7.

- Support for students with Special Educational Needs (SEN), and students who were not online assessment-ready

A small number of students were unable to sit for the online assessment, either because they needed special arrangements or lacked a conducive home environment for online learning. Similar provisions were made for them to be allowed on campus for the online assessments.

- One-on-one interview for students who faced sudden technical issues

During the cFA, students were reminded that they needed to provide evidence of such occurrence for submission to the invigilator. An incident report would be filed and if accepted, the module lecturer would conduct a one-on-one interview, in lieu of the online assessment.

One consideration for the online assessment was the use of custom lockdown browser during the online assessments that would have prevented students from opening other applications or web pages. This was not taken up as that could potentially increase the technical challenge of the online assessments.

Survey of student views of their learning and discussion of results

A survey consisting of 6 statements in a 4-point Likert scale related to student learning and engagement, and three open-ended questions, was conducted with students from all years of studies in SEEE following the completion of the online assessment, cMST. A total of 338 valid completed responses were received.

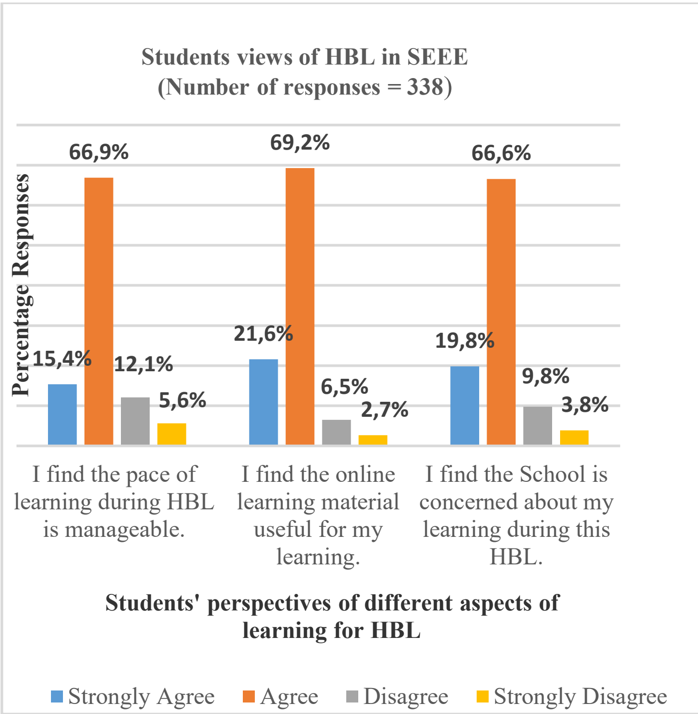

Figure 5 Students' views of HBL in SEEE

Figure 5 shows the responses for students' views on the aspects of learning with the majority of them agreeing that they found the pace of learning during HBL manageable, with 15.4 % strongly agreed and almost 67% agreed. 12.1% of them disagreed on this, while 5.6% strongly disagreed to the statement.

With regard to the usefulness of the online learning material for their learning, a higher percentage strongly agreed (21.6%) and similarly a higher percentage of 69.2% agreed to this, or when combined, almost 91% agreed to the usefulness of the online learning materials.

Almost similar percentages were also recorded for students' views about whether the School was concerned for their learning during HBL with the majority of them indicating positive views concerning their learning and usefulness of the online learning materials and also appreciating the concern of the School for their learning.

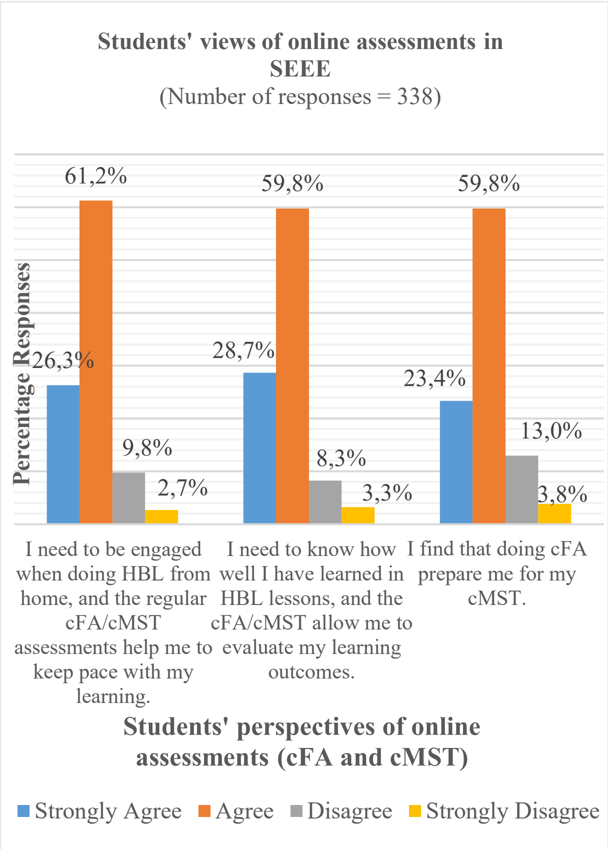

Figure 6 Students views of online assessments vis a vis their engagement in learning, learning outcome evaluation and cMST preparation

Figure 6 shows the responses of the students on their views of the online assessment. 26.3% of the students strongly agreed that the regular assessments helped them to keep pace with their learning, while 61.2% agreed on this. Combined, about 12.5% disagreed and strongly disagreed to this.

A slightly lower percentage of 59.8% of students agreed on whether the cFA and cMST allowed them to evaluate their learning outcome and how well they had learnt. A slightly higher percentage of 26.3% agreed to this view. The combined 11.6% of students who disagreed and strongly disagreed to the view that these assessments enabled them to evaluate their learning. Although at the time of the survey, marks for the online assessments had yet to be revealed, this suggested that students might have a good indication of their learning outcomes, based on their experience and their own gauge of how they had performed for the online assessments. The results so far, suggested that the students had put in the effort to learn in order to prepare for the online assessments and based on how they had performed for the online assessments, they might be able to ascertain and evaluate their own learning outcomes.

On the statement that doing cFA prepared students for the cMST, this recorded the highest combined percentage of 16.8% who disagreed or strongly disagreed.

Results and Discussion of Open-ended Questions

The survey included three open-ended questions as follows:

- What do you like about the online assessment (E.g. cFA, cMST)?
- What do you dislike about the online assessment (E.g. cFA, cMST)?
- What could have been done better for any one of these 3 - Lab video, online learning material and online assessment - to help you in your learning during full HBL?

The 5 favourable factors ranked by students from the highest to the lowest, were open-book online assessment, convenient, helped in learning engagement, provided motivation to study and the experience was not stressful.

The results were as expected. For instance, students appreciated the open-book feature as they were able to refer and look up for information. They enjoyed the convenience of being in the comfort of home without the need to travel during the circuit breaker period. Sitting for the online assessment motivated them to be engaged in their learning so that they were prepared for the online assessments.

The top 5 factors of online assessments that students disliked were lack of time, no backtracking of questions, the upload requirements, stressful and connectivity issues. Unsurprisingly, lack of time was a top grudge for students for all assessments, online or not. The need for no backtracking was perhaps not fully appreciated by students. This feature was incorporated so that there was a degree of authenticity of student assessment, as it tested the student's ability to apply learnt knowledge at that point in time. The upload requirements similarly were needed to provide solutions to questions which were based on higher order thinking skills, which could not be adequately assessed perhaps through multiple-choice questions alone.

Unsurprisingly, the responses received for the third open-ended question were mostly suggestions to address what were the top-ranked dislikes, such as asking for more time, to allow for backtracking and to not have uploads.

On the whole, it could be summarised that students had positive views of the online assessments and appreciated how these helped them to be engaged and also to gauge their learning.

Conclusion and Suggestions for Future Work

The School, as a whole, through the implementation of the fully online assessments, namely cFA and cMST, garnered useful experience and learning. The online assessments were conducted with the aim of engaging students in their learning. The online assessments have enabled evaluation of learning outcomes by teaching staff, and students themselves, through constructive alignment of desired learning outcomes and re-designed teaching and learning approaches, while upholding the high standards of both academic rigor and academic integrity. The views and responses of the students provided useful inputs to help improve the implementation.

Another learning derived from the implementation of the online assessments, was that the School felt that should the semester examination which typically carry 40% weighting, had to be conducted under lockdown conditions, the online mode with e-proctoring could be a possible option with smaller components as follows:

- 10% Assessment 1 – Recapitulation of Knowledge and Comprehension (similar to cFA – with all multiple-choice questions format)
- 15% Assessment 2 – Applied Learning Part 1 (similar to cMST Part 2 of 4 short questions)
- 15% Assessment 3 – Applied Learning Part 2 (similar to cMST Part 2 of 4 short questions)

With this, it is entirely possible to have an equivalent online mode to the paper-based examinations. The School went on to conduct another round of e-proctored online assessments in the subsequent semester to ensure that students who were away from campus in Semester 1 would benefit from a similar experience that their counterparts had undergone earlier.

Acknowledgements

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Remote education under COVID-19 pandemic: using smartphone applications to conduct architectural environmental engineering experiments

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Abstract

The COVID-19 epidemic has forced almost all KOSENs to change their face-to-face lectures in the first semester of 2020 to remote lectures. Instead of distributing video teaching materials, the authors devised a method to utilize the measuring equipment at the student's houses in the subject of Architectural Environmental Experiment for third-grade students in the Department of Architecture at our college. This paper describes the learning outcomes and problems of using a sound level meter application for smartphones at the student's home. The above application displays an instantaneous sound pressure level (SPL) when it is launched. Students wrote down the displayed SPL 10 times every 10 seconds with their smartphone's microphone pointed at the target (noise in their room and living room, ventilation fan noise, etc.). They calculated the equivalent noise level by entering the data into a spreadsheet and summarized the results in a report with discussions. When we checked the submitted reports, we found that about half of the students in the class recorded SPLs in the 20 dB range in their room. We compared the measurement results under the same conditions using the application and a conventional device and found that the former was less sensitive to sounds below 40 dB and above 60 dB. Therefore, it would be necessary for students to use a conventional sound level meter in the face-to-face lecture to provide them with the experience of measuring accurate SPLs. However, the application may be useful for comparing relative SPLs, such as when the ventilation fan is on and when it is off. Based on the results of a questionnaire for students, we found that their understanding of the concept of the equivalent noise level and a noise assessment method was higher after they experienced the measurement with the application than after the measurement outline was explained by us. The authors believe that the experiment using a smartphone application could provide an actual experience that would not have been possible with a distribution of video teaching material and give students an effective understanding of how to investigate the sound environment.

Keywords: *remote lecture, smartphone application, architectural environmental experiment, noise measurement*

Introduction

Architectural environmental engineering is an academic discipline that aims to provide a comfortable and healthy life with energy conservation. This discipline covers wide-ranging topics, including hyperthermia, humidity, sound, ventilation, and light. And it is possible to observe changes in all of these factors in familiar living environments. Evaluating the results of measurements such as temperature, humidity, sound pressure level, wind speed, and illumination based on environmental standards is the key to understanding the discipline. Thus, it is considered effective to conduct experiments along with lectures in the curriculum.

Few experimental teaching materials are available for Architectural environmental engineering in Japan. The educational materials published by the Architectural Institute of Japan (2020) are difficult to apply in our college because they are designed to be taken in one year and include experiments using high-grade measurement equipment. Therefore, in previous years, the authors planned a lecture on the "Architectural Environmental Experiment" by covering a wide range of topics in the field, setting an appropriate season to conduct each experiment when the experimental data is highly affected by weather and climate, and by annually changing and improving the contents based on the students' responses. Tetsu et al. (2010) reported on the content of past lecture.

This lecture was conducted in face-to-face format until the 2019 academic year, but due to the COVID-19 pandemic, it had to be conducted online in 2020. In face-to-face lectures, e-learning -using a learning management system (LMS) as a platform- was already widespread, and the hurdle for conversion to the online format was relatively low. However, it was difficult to convert experimental and practical courses into an online format.

This paper shows how part of the contents of the remote lecture for the Architectural Environmental Experiment was developed at our college using free applications for smartphones to measure sound pressure levels. Here is also discussed the advantages and disadvantages experienced by the authors while using free applications downloaded by students to their own smartphones (iOS or Android devices) as an alternative to conventional measurement devices are summarized. Furthermore, the authors analyze the results of the students' survey to evaluate the educational results of remote learning of experiments using smartphones' application.

Outline of the lecture

The curriculum for the first semester of the third year of the Department of Architecture at our college includes a lecture, once a week for 90 minutes, on "Fundamentals of Environmental Engineering," which is an introduction to architectural environment engineering, and "Architectural Environmental Experiment" related to content learning in Fundamentals of Environmental Engineering. In the experiments, one class of students (about 40 students) was divided into groups of about 6-7 to work on the same experimental task. Each group conducted the experiment, shared, and analyzed the experimental data. Afterward, each student write a report about the experiment. Two teachers and one technical staff member were assigned to assist the students on conducting the experiments and writing reports. Up to two student teaching assistants were usually assigned.

During the first semester of the 2020 academic year, students from our college were not allowed to attend to prevent infection, and the authors were required to conduct the Architectural Environmental Experiment remotely for 44 students. The remote lectures of our college were conducted using Microsoft Teams, an online communication tool, and Moodle, an open-source e-learning platform. Microsoft Teams was used for real-time audio and video distribution, and Moodle was used to provide materials (electronic files) and submission forms of reports. Incidentally, we did not have the support of teaching assistants this year.

For providing students with the experience of measuring and confirming the architectural environment (the indoor environment and the environment around the building), the authors devised an experimental task that utilizes the measurement devices in the students' homes in addition to using Teams and Moodle. One of the tasks was an investigation of the sound environment in their houses using a sound level meter application that measures sound pressure levels using the microphone function of a smartphone.

This investigation was conducted through four lecture sessions. Figure 1 shows the flow diagram of the lectures. The timing of students' survey discussed at the end of this paper is also indicated in the figure. In the first lecture, the teacher explained, via screen sharing, the investigation outline. The document included the purpose of the investigation, basic knowledge of sound and noise including the overview of the equivalent noise level and several noise evaluation criteria, some reference materials for data processing and report writing, and an

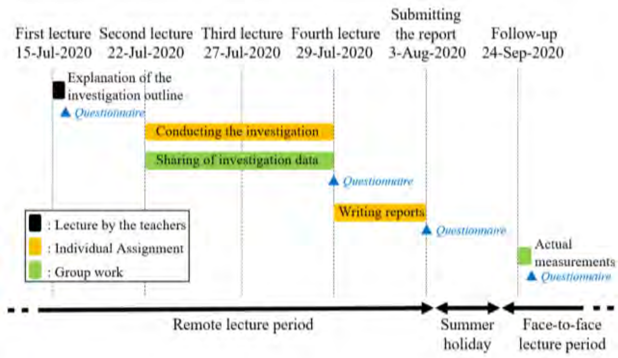

Figure 1 Investigation flow diagram

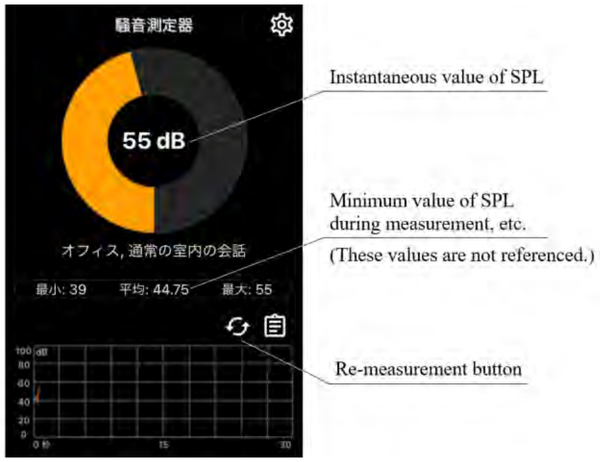

Figure 2 Screenshot of the app for iOS

overview of the investigation. The electronic files of the document were uploaded to Moodle so that students could refer to them at any time. The authors also pasted links to websites that would be helpful for this study. In the second and third lectures, the students conducted the investigation and shared the investigation data with the group. In the fourth lecture, they wrote a report summarizing the results and discussion of the investigation. The investigation and its redo could be conducted freely by them, including outside of lecture time until the fourth lecture. As a follow-up to this lecture, the authors provided an opportunity for students to experience actual measurement using conventional measurement equipment (a sound level meter) after the college resumed its face-to-face lectures.

Overview of sound environment investigation

The purpose of this investigation is to learn how to measure and analyze the sound pressure level of the students' surrounding sound environment under remote lectures, specifically the indoor noise associated with their daily activities. Instead of a sound level meter, they used Simple Sound Meter (GWI JU JO, for iOS) and Sound Meter (Abc Apps, for Android), which are free applications that display instantaneous sound pressure levels when pointed at a built-in microphone on a smartphone. Figure 2 shows a screenshot of when the application for iOS is launched, and the application for

Android has a similar content. The following points were considered when selecting the smartphone application: As the students are under 18 years of age, they often require parental permission to install applications. Therefore, attention was paid to the amount of advertisements displayed on the applications. In addition, the authors tried several candidate applications and selected those whose functions and performance did not change significantly on different operating systems.

The sound pressure level was measured by pointing the smartphone's microphone at the measurement target at 1.2 m from the floor or at the student's ear height and recording the instantaneous value displayed on the application and the sound heard at that moment 10 times every 10 seconds. As a precaution, the authors informed the students that they should check the operating status of nearby electrical devices such as personal computers and refrigerators, check if the windows were open or closed, and that unexpected sound reflection effects may occur when the smartphone is placed on a shelf. The students entered the measurement results into Excel, created graphs for each condition, and calculated the equivalent noise levels. Based on the graphs and calculations, they discussed the measurement results by understanding the characteristics of each measurement condition at different locations and times of the day and comparing them with various index values described below.

The measurement conditions are presented in Table 1. Condition I is a background noise measurement in a situation where students are usually taking remote lectures, which is regarded as a learning environment and evaluated by comparing it with the recommended indoor noise values for school facilities in AIJES-S0001 (2008) (Table 2). Condition II is a measurement in the student's private room with one window open, and the microphone pointed outdoors to record the external noise entering the room from outside. Condition II-1 was measured during the day (6:00 a.m. to 10:00 p.m.), and condition II-2 was measured during the night (10:00 p.m. to 6:00 a.m.). In both conditions, measurements were required on a sunny and windless day to avoid the influence of rain and wind noise. These results were evaluated by considering the distance from the main road and comparing it to the environmental standards of the Ministry of Environment in Japan (Table 3). To measure the distance between the main road and the student's house, they used a browser tool that can find the straight-line distance between two pins on Google Maps. For condition III, to understand the increase in sound pressure level due to ventilation equipment, measurements were made of the steady-state noise when the ventilation fan was on in the toilet or bathroom (condition III-1), and the background noise when it was off (condition III-2). Condition IV was measured in an ordinary living room and was evaluated by comparing it with the index value of the equivalent noise level (L_{Aeq},T [dB]) related to the daily life noise in a certain municipality.

Table 1 Measurement location and target

Condition No.	Location	Target
I	Room for taking remote lectures	Background noise (Excluding audio from PC)
II-1	Window side of a student's private room	External noise with one window open (6 a.m. to 10 p.m.)
II-2		External noise with one window open (10 p.m. to 6 a.m.)
III-1	Toilet or bathroom	Steady-state noise of ventilation fan (Turn on the fan)
III-2		Background noise (Turn off the fan)
IV	Center of the living room	Daily life noise

Table 2 Recommended values for indoor noise in school facilities

Room or location	Recommended value ($L_{Aeq,T}$)
Rooms where quiet is required (music rooms, auditoriums, infirmary, etc.)	35 dB
Rooms where quiet is desirable (classrooms, craft rooms, staff rooms, etc.)	40 dB
Rooms that require less quietness (gymnasium, indoor pool, etc.)	45 dB

Table 3 Environmental standards for general areas

Regional Typology	Reference value	
	Daytime	Night time
AA	Less than 50 dB	Less than 40 dB
A and B	Less than 55 dB	Less than 45 dB
C	Less than 60 dB	Less than 50 dB

*Regional typologies are mainly categorized by the urban function induction area and zoning.

The measurement results and the calculation values of the equivalent noise levels of conditions I and II were shared with the group. There are two reasons for sharing the investigation data: first, to enable the students to compare their measurement results with those of the group members to examine their validity. It is also possible to let the students judge whether their measured sound environment is noisy or quiet. Second, the data was shared to promote communication among students. For example, since students have different levels of understanding of the investigation overview and skills in using spreadsheet software, students were encouraged to support each other. Teachers and technical staff provide support as needed. However, it was difficult to respond as quickly as in face-to-face lectures because it is not possible to see the students in real-time in remote lectures. In face-to-face lectures, minor problems could be solved through discussion among students; thus, the authors believe that it is important to promote this kind of communication among students, even in remote lectures.

Advantages and disadvantages of the smartphone application

From the reports submitted by the students, the authors confirmed the measurement results of the sound pressure level with the smartphone application. In condition I, about half of them in the class recorded instantaneous values in the 20 dB range at least once. In terms of the A-weighted sound pressure level, 20 dB is the lower limit of measurement using a sound level meter, which is a value that rarely appears even when measured in an anechoic room. This is not a problem limited to the application used in this lecture, but in general, the measurement system of smartphone applications is rarely explicitly stated. Therefore, the details of the accuracy of sound pressure level measurement by the smartphone application used in this lecture will not be discussed. This is disadvantageous because the values measured by the smartphone application are different from those measured by conventional measuring instruments, and the smartphone application may not provide accurate measurements.

As a reference, Table 4 shows some examples of measurements made by the author using the smartphone application used in this lecture and a conventional sound level meter. From the measurement results of the background noise level and the noise level while playing music on the speaker, it was found that the applications used in this lecture found it difficult to detect sounds below 40 dB and above 60 dB, and this tendency was conspicuous in the iOS apps. Incidentally, smartphone cover had almost no effect on the measured values.

However, it is impractical in terms of time or cost to prepare (buy and mail to students' homes) conventional measuring instruments for the whole class. As mentioned above, the free smartphone application cannot be used as a complete replacement for conventional instruments, but it can be used immediately and at any time, once downloaded. For example, if a student wants to know how much the sound pressure level differs in the same place in the morning and at night, he can easily measure it outside of lecture hours with a smartphone application. This is considered to create greater interest among students regarding the sound environment.

The authors also believe that smartphone applications have value because they can unify the tools used by students in remote lectures. For example, in this investigation, since each student took measurements at home, the measurement location differed from one student to another. Even in this situation, it is possible to judge whether the measurements are valid by comparing the measurement results of students who used the same application (with the same OS). Subsequently, some of the students questioned the accuracy of the application's measurements.

Table 4 Comparison of measurement values by a sound level meter and the smartphone applications

Measurement target	Measurement value		
	Sound level meter	Android app	iOS app
Background noise level	37 dB	38 dB	49 dB
Noise level while playing music on the speaker	69 dB	63 dB	60 dB

It is necessary to make students understand that smartphone applications grasp the rough sound pressure level but cannot make accurate measurements. The smartphone applications would then be useful for learning how to measure the sound pressure level and compare the relative sound pressure levels under various measurement conditions.

Verification of educational effectiveness

To evaluate the educational effect of sound environment investigation using smartphone applications in this remotely conducted lecture, using a web-based questionnaire, the authors executed a survey with the students, where they self-evaluated their understanding level. The survey was conducted four times using the questionnaire function of Moodle, as shown in Figure 1: 1 when the overview of the sound environment investigation was explained by the teachers (after the first lecture), 2 when the investigation was completed (after the fourth lecture), 3 when the report summarizing the investigation results was submitted (after submitting the report), and 4 when the students experienced the actual measurement using a sound level meter as a conventional instrument (after follow-up). The students selected a numerical value for the items in Table 5 on a scale of 1 to 5. 1: do not think so at all, 2: do not think so, 3: somewhat do not think so, 4: somewhat think so, 5: think so, and 6: think so completely. All of whom attended the lecture, 44 students, answered the questionnaire in all four sessions. However, Question 2 was excluded from the after follow-up questionnaire that no smartphone applications was used for measurement.

Figure 3 shows in a radar chart the average value of all student questionnaire results. Clearly, the students' understanding of how to measure noise levels using sound level meters (Question 1), concept of equivalent noise level (Question 3), calculation of equivalent noise level (Question 4), evaluation of noise levels (Question 5), high or low noise levels (Question 6), and interest in sound (Question 7) increased as the lecture progressed. The equivalent noise level was the least understood in the first lecture because it was a developmental subject, although the outline was taught in the lecture on the Fundamentals of Environmental Engineering. However, the students seemed to have learned how to calculate the equivalent noise level through report writing. From the questionnaire results for Question 2, the students also answered that they gained a deeper understanding of how to measure the sound pressure level using smartphone applications as the lecture progressed.

Question 8 asked whether the students could cooperate with their group members to compare and discuss the measurement results and communicate with other students; it was also evaluated gradually as the lecture progressed. The highest evaluation was obtained during the actual measurements in the follow-up. Regarding the mood of the students, the level of understanding of the experiment process was low at the first lecture, and seemingly, it was difficult for them to take the initiative and show leadership during group discussions in the private channel in Teams. As students gradually got used to the online activities, communication among them became more active, including calling out to less responsive group members. Additionally, it was observed that tasks such as comparing measurement results and creating shared files proceeded smoothly.

Conclusions

The authors believe that remote lectures using smartphone applications have shown a certain educational effect as an example of a practical method for experimental subjects in the COVID-19 vortex. However, some smartphone applications can be disadvantageous due to inaccurate measurements, which can cause problems that teachers cannot prevent in advance, such as measurement results which are impossible with conventional measuring instruments. Therefore, it is recommended to take precautions when using smartphone applications in remote lectures and provide opportunities to take measurements using conventional measuring instruments in face-to-face lectures.

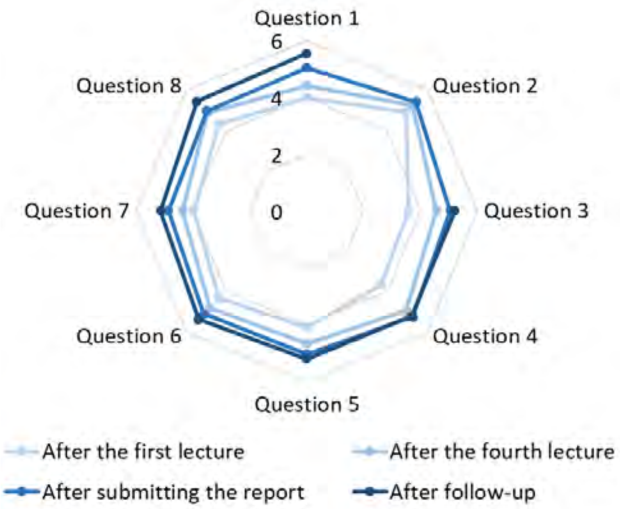

Figure 3 Radar chart of students' self-assessment

Table 5 Student' self-assessment items

Question No.	Items
1	To be able to understand how to measure noise level using a sound level meter.
2	To be able to understand how to measure noise level using a smartphone application for sound level meters.
3	To be able to understand the concept of equivalent sound level.
4	To be able to understand the calculation method of equivalent noise level.
5	Understood how to evaluate the measured noise level with various index values.
6	Understood when the noise level becomes higher or lower.
7	Increased my interest in sound.
8	To be able to cooperate with my group members.

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DEVELOPMENT OF AN ARTIFICIALLY INTELLIGENT TUTOR CHATBOT FOR ENGINEERING EDUCATION INNOVATION

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Abstract

The advances of technology in the modern world has dramatically changed the learning processes of students. Chatbots are computer programs that use artificial intelligence and machine learning to conduct conversation via auditory or textual methods. In this study, a pilot chatbot to answer Frequently Asked Questions of the syllabus of a selected module was created and implemented in a role of intelligent tutor. We investigate the feasibility of using a chatbot and further enhance the model to support tutoring with negotiation techniques. The chatbot accepts textual input from users, navigates through the Information Repository (IR) and responds with student information in text. With its focus on using student-generated data to build the IR, this study can be a valuable component for engineering education to improve practical skills acquisition and to assist students' learning. In this article, we present the development and capabilities of the conversational agent (i.e. the chatbot), the chatting log architecture and applications in engineering education. Future directions of the implementation of the chatbot are included so as to improve the chatbot and offer a fully developed chatbot that enhances students experience. This technology, if successful, could have widespread application in schools, institutions and other training scenarios for engineering education innovation.

Keywords: *artificial intelligence, chatbot, intelligent tutoring, engineering education, innovation, STEM education.*

Introduction

Due to the world pandemic, the learning experience of students has dramatic change. A face-to-face lesson in the classroom on a regular schedule is no longer the norm of study. Mobile learning with technology such as AI chatbot is now become the trend in the education sector. In this paper, we explore the possibility of using AI chatbot tutor to assist teachers to achieve this goal. First, we will explain the architecture and neural network model of the AI chatbot tutor and followed by a survey on students and teachers to get their opinion on using AI chatbot tutor for learning and teaching.

Literature Reviews

There are different researches on using AI chatbot in education, for example, S. Studente [1] introducing a chatbot to develop learning communities in higher education which proved to increase students' engagement. In engineering education, Sherif A. and Andrew K [2] using chatbots as smart teaching assistants for the first-year engineering students and have a positive finding that chatbot can provide faster result than manually searching paper-based textbooks. When developing AI chatbot, one challenge is known students's intention through their message, György Molnár and Zoltán Szűts [4] overview the history of chatbot and also mention that the ability of chatbots should evolve over time through their evaluating chat conversations. Other than query and chatting function, there is HKU integrated AI chatbot into their curriculum for The Science of Crime Investigation, for helping students analysing forensic evidence in a criminal investigation through gamification [6]. Therefore, there is great potential for AI chatbot tutor to enhanced students learning experience under the new normal.

Architecture

Since WhatsApp is one of the major instant massager in Hong Kong, most students have WhatsApp account. In our pilot study, we developed an AI chatbot tutor to respond their query through WhatsApp text message. In this situation, students no need to install any apps into their mobile phone. The infrastructure of the AI chatbot tutor was shown in Figure 1.

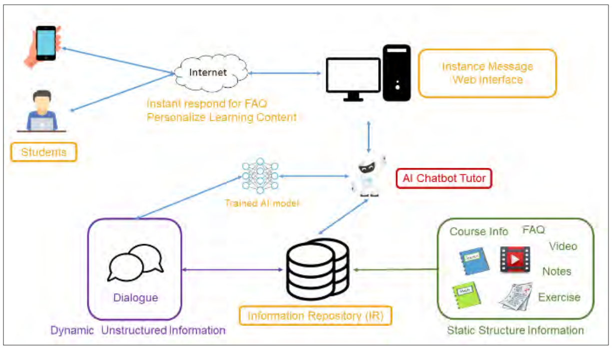

Figure 1: AI chatbot tutor architecture

The main module is a python program which attached to the web interface of instant messaging (which is WhatsApp web interface) to retrieve messages from the students and respond to them. When the AI chatbot tutor received a message, it will pass it to the trained neural network model to evaluate his/her intention. Then retrieve the corresponding information from the Information Repository (IR) and reply it to the students. The Information Repository of the system contains two parts: The first part is statistic structured information related to the courses information: such as video links, lecture notes, frequency asked question (FAQ), syllabus, etc… The second part is dynamic unstructured information: all dialogues message between students and AI chatbot tutor are store in here.

Figure 2 show the neural network model of our AI chatbot tutor. It contains three layers: the input layer is the encoded format of the text message using a bag of words, followed by a hidden layer with 64 neurons, then is the output layer which is the cetology of the intention: greeting, syllabus, timetable, etc… that students want to do. Then base the intention, retrieve corresponding static information from the Information Repository (IR).

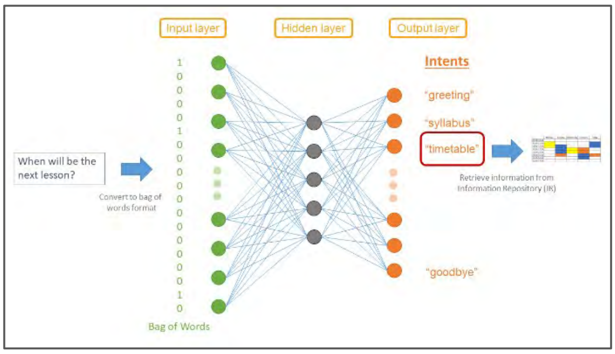

Figure 2: Neural network model of AI chatbot tutor

The most difficult part for AI chatbot tutor is provide precise and actuate respond to the students to solve their problem or query. That means that we need to know their exact intension through their text messages. Therefore we need to keep update to train the model with the dialogue information. We store all the dialogue into the IR for further training and also use as personalised profile for the students.

The pilot run show positive feedback that AI chatbot tutor can provide useful course information to the students. In order to further enhance the AI chatbot tutor, a survey was conducted for 36 participants (21 teachers and 15 students) to gather their views on AI chatbot tutor. Results are show on next session.

Results and Discussion

In our survey, all of the participants showing a positive view (score 7.22 out of 10) that AI chatbot tutor can assist in the teacher's teaching. On the other hand, they are disagreed (score: 4.33 out of 10) that in near future AI chatbot tutor can replace the teacher's teaching duty.

Figure 3 show the main purpose of using AI chatbot tutor. They are to query course/module basic information (83.3%), to ask FAQ type questions (77.8%) and to ask questions related to notes/lessons (69.4%). It reveals that AI chatbot tutor is suitable for basic query services.

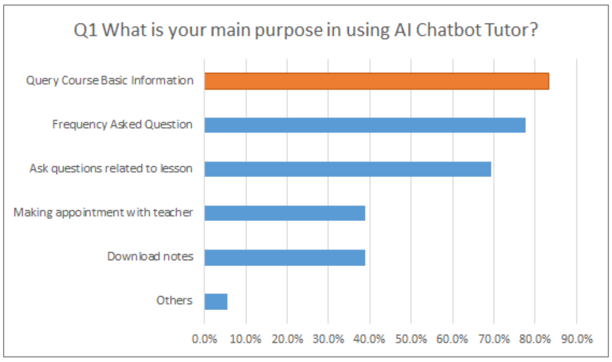

Figure 3: Survey result of Q1

Figure 4 show the participants' preference platform for launching AI chatbot tutor, the top three are: Mobile App (33%), Learning Management System (LMS) (24%) and WhatsApp (17%) / Website (17%).

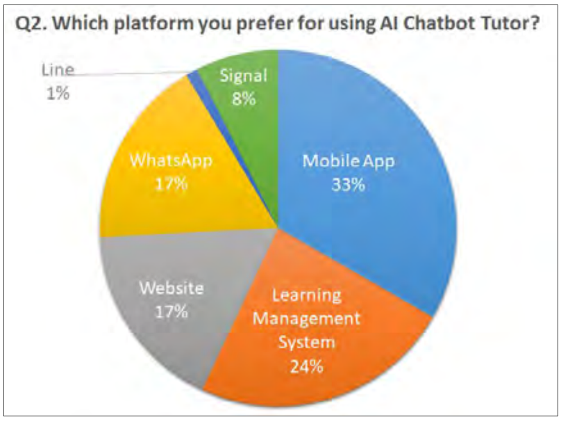

Figure 4: Survey result of Q2

Figure 5 show that Language (75%) and Engineering (61%) are the top two subjects that suitable for using AI chatbot for learning and teaching.

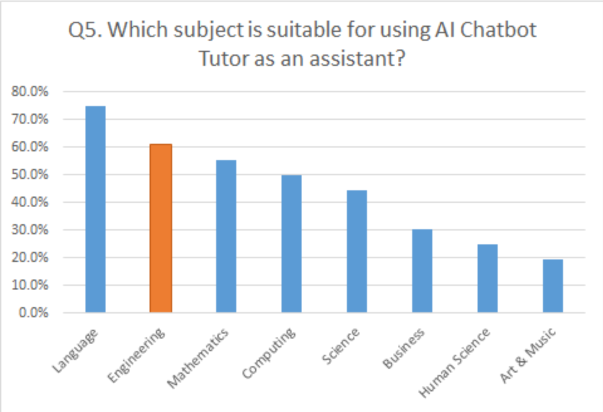

Figure 5: Survey result of Q5

The major advantage of AI chatbot tutor is instant response (94.4%), service anytime and anywhere (80.6%) and can provide personalised content (61.1%). On the other hand, the disadvantages are cannot provide humanize dialogue (75%), the response may irreverent (63.9%), students may rely on it (50%).

Other than basic chatting and query functions, the participant suggested including data analysis and personal assistant function into the AI chatbot tutor.

Conclusions

Due to the world pandemic, online/mobile learning with the use of technology becomes a norm under the new normal. In this paper, we propose an infrastructure to build an AI chatbot tutor for engineering education innovation, it shows positive feedback from students in the pilot run. Also in our survey, both teachers and students agreed that AI chatbot tutor can enhance students' learning experience with the features, such as instant response and 7/24 service time.

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Appendix 1: Survey Questions and Result

Question	Result
Q1. What is your main purpose in using AI chatbot tutor? (Multiple selections is allowed)	Query course basic info (83.3%) FAQ (77.8%) Ask questions about the lesson (69.4%)
Q2. Which platform is suitable for launching AI chatbot tutor? (Multiple selection is allowed)	Mobile app (33%) Learning Management System (24%) WhatsApp (17%) Website (17%)
Q3. What is the advantage of using AI chatbot tutor? (Multiple selections is allowed)	Instant response (94.4%) 7/24 Service (80.6%) Personalize content (61.1%)
Q4. What is the disadvantage of using AI chatbot tutor? (Multiple selections is allowed)	Cannot provide humanized dialogue (75%) Respond reply is irrelavent (63.9%)
Q5. Which subject is suitable for using AI chatbot tutor as an assistant? (Multiple selection is allowed)	Language (75%) Engeering (61.1%) Mathematics (55.6%)
Q6. Other than the chat function, any function you want to include in the system? • Personalize assistant • Handling administration work • Reminding	
Q7. Do you agree that AI chatbot tutor can help with a teacher's teaching duty? (Score: 1- Strongly disagreed 10- Strongly agreed)	7.22
Q8. Do you agree that AI chatbot tutor can replace a teacher in near future? (Score: 1- Strongly disagreed 10- Strongly Agreed)	4.33
Q9. Any suggestion on AI chatbot tutor? • Helping a teacher to summarise the learning status/profile of their students. • Provide graphic and data analysis result.	

EFFECTS AND ISSUES OF ACCEPTING PROGRAM FOR SHORT-TERM INTERNATIONAL STUDENTS

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Abstract

With the progress of globalization of industry, not only the technical ability but also high communication ability in English is required. Therefore, to foster students as global engineers who can play an active role in the world, many technical colleges not only send their students overseas to learn English, but also accept short-term international students for academic exchange activities to improve student's international communication skills and to promote the internationalization of colleges campuses.

Hiroshima College, National Institute of Technology (KOSEN) in Japan, launched its overseas English training program at Emilio Aguinaldo College in the Philippines in 2009. Every summer vacation, a few or dozens of students visit Manila of the Philippines and take two-week English training lessons that are a one-on-one English conversation training program. From 2010, as an academic exchange program, Hiroshima College started to accept short-term international students for two weeks from Emilio Aguinaldo College, AMA Computer University, and Saint Michael's College of Laguna in the Philippines every autumn. During the two weeks, the Filipino students join the classes to take the lectures and workshops on academic and technical subjects of the college, visit an elementary school and junior school to help their English lessons, visit historical sites, local factories and companies, practice Zazen meditation and learn Japanese tea ceremony to experience the Japanese cultures, support the tournament of KOSEN Robot Contest (a competition of self-made robots), In particular, the Filipino students actively participate in an English Dojo (English learning group) at the student dormitory, it does improve the students' international communication skills and promote mutual understandings and friendships by teaching their languages

In this paper, the details and transitions of the program of accepting short-term international students are reported, including the daily schedules, the questionnaire survey results, the active learning effects and ripple effects to Japanese students, and the cost performance to improve the students' English communication skills, especially the issues that exist in this program are discussed. Finally, some remedies are also proposed.

Keywords: *Active Learning, Accepting Program, Short-term International Students, Effects, Issues.*

Introduction

Hiroshima College of KOSEN was founded in 1898 and was formerly known as Hiroshima National College of Maritime Technology, it has a long traditional history of 123 years and is one of five national colleges of maritime technology in Japan. Hiroshima College has about 100 teachers and staff, and about 700 students are studying and living in a beautiful campus surrounded by the blue sea and green trees (Figure 1). There are 3 academic departments which are the Department of Maritime Technology, the Department of Electronic Control Engineering, and the Department of Distribution and Information Engineering. Hiroshima college strives to produce young practical engineers of ability in a five-year higher education system along with two more years of advanced courses to meet the strong demand from industry including the shipping industry.

Figure 1 Top view of campus of Hiroshima College

From 2000 to 2015, Hiroshima College signed the academic exchange agreements separately with the University of the Philippines Diliman (August 27, 2001), AMA Computer University (August 29, 2002), Emilio Aguinaldo College (May 26, 2009), and Saint Michael's College of Laguna (September 3, 2015). These are all located in Metro Manila of the Philippines.

In almost every summer vacation since 2006, Hiroshima College sends a few or dozens of students to visit Manila of the Philippines and take two-week English training lessons that is a one-on-one English conversation training program. We have reported these dispatching programs in ISATE 2019 (Transactions of ISATE2019 Paper ID: 3050418).

Hiroshima College started to accept short-term international students for two weeks from Emilio Aguinaldo College, AMA Computer University, and Saint Michael's College of Laguna in the Philippines almost every autumn since 2010. Table 1 shows the participant numbers every year from the three colleges.

Table 1 Accepting Program from the 3 Colleges

Participants Year	EAC		AMA		SMCL	
	T	S	T	S	T	S
2010	1	3	-	-	-	-
2011	-	-	-	-	-	-
2012	-	-	1	4	-	-
2013	-	-	1	7	-	-
2014	1	3	1	9	-	-
2015	-	-	-	-	-	-
2016	-	-	-	-	1	4
2017	1	3	-	-	1	6
2018	-	4	-	-	-	-
2019	-	2	-	-	-	-
2020	-	-	-	-	-	-

*Abbreviation of letters above
EAC: Emilio Aguinaldo College
AMA: AMA Computer University
SMCL: Saint Michael's College of Laguna
T: Participants of teachers
S: Participants of students

As shown in above Table 1, the acceptance of short-term students from Philippine academic partner colleges began in 2010 with three students from EAC, and since then, there have been some years (2011, 2015, 2020) when there were no students accepted, but the program has continued regularly every autumn.

Regarding the expenses in the acceptance program, in principle, travel and accommodation expenses are borne by each participant. But since the participants' accommodation was arranged at a welfare facility named Wakashio Kaikan, it is free of charge. However, the round-trip airfare from Manila to Hiroshima is expensive for Filipino students, hence Emilio Aguinaldo College covered their students' airfare, but the students from AMA Computer University and Saint Michael's College of Laguna are self-financed by their parents, so most of the participants seem to be from well-to-do families.

In the year 2020, we did not accept short-term students from abroad due to the pandemic of Coronavirus disease 2019 (COVID-19), so we will present details of the acceptance of students in the year 2018 and 2019 and report on the effects and the problems that exist.

Accepting program in the year 2018

In 2018, four students participated in the short-term exchange program held by Hiroshima College; they were two girls and two boys from the Cavite campus of Emilio Aguinaldo College (EAC).

Table 2 Schedule of 2018 short-term exchange program

Date	Programme (Lessons / Activities)
Oct. 13 (Sat.)	20:40 Arrived at Hiroshima airport CI112, Staying at Toyoko-Inn Higashi-Hiroshima
Oct. 14 (Sun.)	Touring① Saijo Sakakura Dori (Morning) Touring② Takehara City (Afternoon)
Oct. 15 (Mon.)	Opening Ceremony Hiroshima College Orientation Lesson① D3 English III Lesson⑯ International Students Exchange Welcome Party
Oct. 16 (Tue.)	Touring③ Osakikamijima Island Visit① Toho Zinc Chigirishima Refinery Japanese Tea Ceremony
Oct. 17 (Wed.)	Lesson② M2 Maritime English Lesson③ M3 English III Lesson④ M5 Engine Experiment Lesson⑰ English Doji (English Speaking)
Oct. 18 (Thu.)	Lesson⑤ MN5 Marine Weather Lesson⑥ MN5 Enjoy Navigation Lesson⑦ D5 Information Security
Oct. 19 (Fri.)	Visit② the Great Mochizuki House Visit③ Okamoto Soy Sauce Brewery Lesson⑧ C3 English expression III Briefing for the weekend field trip
Oct 20 (Sat.)	Field Trip (Hiroshima City) Touring④ the world heritage Miyajima Island, Itsukushima Shrine Hiroshima Peace Memorial Museum
Oct. 21 (Sun.)	Field Trip (Robo-Con) Touring⑤ Matsue City, Shimane Kashima General Gymnasium Watching KOSEN Robot Contest
Oct. 22 (Mon.)	Lesson⑨ Programming for LEGO NXT Lesson⑩ Training ship experience (Hiroshima-maru)
Oct. 23 (Tue.)	Lesson⑪ A1 English presentation Lesson⑫ AI2 Image Processing Lesson⑬ D5 Graduation research Lesson⑱ English Doji (English Speaking)
Oct. 24 (Wed.)	Lesson⑭ C5 Graduation research Lesson⑮ C3 Introduction to Sequence Control
Oct. 25 (Thu.)	Visit④ Higashino Elementary School Observe class and enjoy the school lunch Visit⑤ Seikouji temple Do Zazen meditation experience
Oct. 26 (Fri.)	Visit⑥ Matsuura Shipyard Visit⑦ Kinoe Fureai Regional Museum Report and Questionnaire Closing Ceremony
Oct. 27 (Sat.)	Hiroshima College Festival Freely participate in the whole day
Oct. 28 (Sun.)	9:00 Depart from Hiroshima airport for Manila via Taipei airport by CI113

The schedule of the 2018 short-term exchange program for the two weeks from October 13 to October 28 is shown in Table 2. The meanings of the abbreviations in Table 2 are as follows:

D3: 3rd grade class of Department of Distribution and Information Engineering, D5 has similar meaning.

M2: 2nd grade class of the Department of Maritime Technology, M3 and M5 have similar meanings.

MN5: 5th grade class of the Navigation Course of Department of Maritime Technology.

C3: 3rd grade class of Department of Electronic Control Engineering, C5 has similar meaning.

A1: 1st grade class of Advanced Course.

AI2: 2nd grade class of Advanced Course of Industry System Engineering.

As shown in Table 2, during the accepting program, the short-term exchange Filipino students joined lots of classes and took 18 lessons of the lectures and workshops on academic and technical subjects of Hiroshima College, visited 7 Japanese organizational facilities including local factories and companies, elementary school, historical sites, Japanese temple, and Regional museum, etc., and took on five tours of local cities and sightseeing spots, including the famous world heritages in Hiroshima and watching the KOSEN Robot Contest.

1. Opening ceremony and welcome party

On the first weekday (Monday, October 15), Hiroshima College held an opening ceremony and a welcome party to welcome Filipino students and gave them the orientation of the short-term exchange program.

2. International students exchange meeting

There are long-term international students at Hiroshima College, and we held an exchange meeting among them to discuss Japanese culture and Japanese language study.

3. Lessons of the lectures and workshops

During the two weeks accepting program, the Filipino students joined lots of classes and took 18 general and specific lessons of the lectures and workshops on academic and technical subjects.

4. Visit of Japanese organizational facilities

The short-term exchange students visited 7 Japanese organizational facilities during the two weeks program. Figure 4 shows that they were visiting Matsuura shipyard and watching the launching ceremony of a new ship.

5. Tours of sightseeing spots and Robo-Con

The short-term exchange students took on five tours of local cities and sightseeing spots, including Itsukushima Shrine in Miyajima Island and Hiroshima Peace Memorial Museum, both are the famous world heritages in Hiroshima city, and they went to watch the KOSEN Robot Contest (Robo-Con) which was held in Matsue city, Shimane prefecture.

6. Closing ceremony and farewell speech

The closing ceremony was held on the last weekday (Friday, October 26), every Filipino student gave her/his farewell speech and answered the questionnaire. The last Saturday (October 27), there was a college festival at Hiroshima College, so the Filipino students were free to participate and enjoyed the events that whole day.

Accepting program in the year 2019

In 2019, Hiroshima College sent invitation letters to three partner colleges in the Philippines: AMA Computer University, Emilio Aguinaldo College, and Saint Michael's College of Laguna. However, after a lot of coordination and communication with the person in charge at the partner colleges, only two students from EAC participated in the 2019 short-term exchange program.

Both girls were 5th-grade students of the Engineering Department from the Cavite campus of EAC. One’s specialized field was Mechanical Engineering, and the other specialized in Electronics Engineering.

Also, should be highlighted that EAC paid for their round-trip airfare from Manila to Hiroshima.

The 2019 short-term academic exchange program, which began on October 22 and ended on November 2, also lasted for two weeks, had a similar schedule as 2018, so we omit the further details, only a few of interesting exchange activities are briefly described here.

7. Steering a ship in the inland sea near the school

Hiroshima College has a practice ship named Hiroshima-Maru, which has 234 gross tonnages. The students can steer the practice ship at Hiroshima College even without a marine license. Figure 2 shows the two girls trying to steer the ship under the guidance of a navigator while they were visiting the practice ship.

Figure 2 Visit and steer the Hiroshima-Maru ship

8. English conversation gathering at English Dojo

The two Philippine girls are lively, cheerful, and approachable. Almost every evening they attracted a group of students to hold an English conversation gathering which was called English Dojo at Wakashio clubhouse where they lived. The two girls personally cooked some meals. The students ate and drank while talking in English, which greatly promoted the students' interest and initiative in learning English and was highly appreciated by the teachers and students.

Evaluation of short-term accepting program

At the end of the last day of the short-term exchange program each year, we conducted a questionnaire for the international students who attended the program. Here are some of the questions from the 2018 and 2019 questionnaires and the student’s responses. The A1-A4 are the responses of four students in 2018, and A5-A6 are the responses of two students in 2019.

Q1. How were the lessons or lectures or workshops?

Q1.1 -The two most valuable ones.
A1: All of the lessons we attended had been so great for me, but the two most valuable ones would be the C programming for LEGO NXT and the experience of steering a training ship.
A2: The C programming for LEGO NXT, English III.
A3: C programming for LEGO NXT and English Dojo.
A4: LEGO NXT PROGRAMMING, it was such great lectures, and it caught my attention and interest. Image Processing, this lesson helps me to have information and ideas for my research project.
A5: The two most valuable lectures for me were the General English class and the Training Ship Experience at the Hiroshima-Maru. Participating in classes with the students was so fun and unforgettable.
A6: The two most valuable lessons for me are the Constitutional Law and the General English Class. In the former class, the teacher and students cooked Japanese food for us and that was very heart-warming. In the latter class, we gathered a lot of friends and got to share things about the Philippines.

Q1.2-The one you do not want to take again (and why?)
A1: I like all the lessons so there’s really nothing that I do not want to take again.
A2: NONE
A3: None
A4: NONE, because all of the lessons, lectures and workshops that I attended were nice and I learned a lot.
A5: If there is one lesson I would not want to take again, it would be the Programming Class, because it’s kind of boring to just play computer puzzles.
A6: Programming I

Q1.3-Other lessons or lectures you would like to take next time.
A1: I guess I would like to take more lessons about electronics and math.
A2: The Programming for Image Processing, The information security, The Introduction of Sequence Control.
A3: More computer related topics.
A4: Information technology and programming lessons.
A5: I personally would like to see students working on their Graduation Research, I think I will learn a lot from them.
A6: I would like to take again next time the Training Ship Experience and C Programming LEGO NXT.

Q2. Write down some remarks about:

Q2.1-The Field trips
A1: I had fun going to Miyajima with some of our Japanese friends to see the famous Itsukushima Shrine, the Okonomiyaki and Momiji Manjoo are really delicious.
A2: Very beautiful place and fun experience with some of the students.
A3: I enjoyed it very much, Amazing history of Hiroshima.
A4: Overall field trip experience was so memorable.
A5: The field trip was the best weekend/ 21st birthday I’ve had. Traveling around the city for hours with our Japanese friends is really fun.
A6: We visited some famous museums and historical sites in Miyajima. It was a fun two days. The food is also delicious.

Q2.2-The Elementary School
A1: When we visited the elementary school, I got a glimpse of how trained and disciplined the Japanese education is, even at a young age, the children ate responsible, very well disciplined already.
A2: Happy to see the children at a every young age they can be independent and fun to play with.
A3: The children ate so polite, industrious and kind.
A4: The kids were all lively and friendly. I noticed that they learned how to be independent such as preparing their lunch meal and cleaning.
A5: This experience is really one of a kind. To have interactions with the future of this island and to actively interact with kids is quite relaxing.
A6: It is an opportunity for me to see the Elementary School because it shows me how Japanese pupils start their education from a young age.

Q2.3-The Mochizuki House
A1: At the Mochizuki House, I learned about the history of NIT, Hiroshima College. It was founded by great people and even made greater through time.
A2: A beautiful museum that shows historical events of the past.
A3: Magnificent place, learned things about the origin of this school.
A4: Even though many years have already passed, the place still looks magnificent.
A5: This was also amazing, being able to roam around a house of a former politician and knowing it’s a part of history is very interesting.
A6: The house is very beautiful, I can’t help but wonder how Japanese people lived before. The architecture and engineering are amazing.

Q2.4-The Japanese Temple
A1: Japan is known to have many famous temples throughout Asia. This is something that they value because I know that temples have been a part of their culture and history.
A2: Interesting, about their teachings and their everyday life at the temple.
A3: Majestic place, and a peaceful place.
A4: Very religious and peaceful place.
A5: This is really relaxing. To learn new knowledge and to try it ourselves, to learn new culture is really amazing and memorable.
A6: I love the experience. I get to experience meditation, it's very relaxing, the place is so beautiful and peaceful.

Q2.5-The Hiroshima Peace Memorial Museum
A1: Visiting the Hiroshima Peace Memorial Museum is a rewritable experience for me. I love to read about history, and I have read about the atomic bombing of Hiroshima to see the place where history had taken place is a great experience for me.
A2: Sad about what happened to Hiroshima and amazed about the Peace Memorial Park and Museum.
A3: A very historical place, elegant and a place to remember that war is not the answer.
A4: The story behind the Hiroshima Peace Memorial Museum touched my heart and made me feel emotional.
A5: This has touched me. It broke my heart; this is a place I will definitely want to come back again.
A6: The place was nice, and I am so happy that I learned a lot about Hiroshima, the bombing and about peace.

Q2.6-The Robot Contest
A1: Japan takes pride for its high technology and advancement on that field. It was fun and amazing to watch the Robot contest.
A2: Amazed about the Robots the students made but a little bit sad that we didn't finish watching the contest.
A3: Exciting competition, and I feel proud because Hiroshima College won the game.
A4: The students who participated were all great, especially Hiroshima Shosen for being the champion.
A5: I'm so interested in this. Sadly, it was really far so we did not have the time to finish the contest. All the students were amazing.
A6: The students are all awesome. They are all very talented and smart. The technology of Japan is really advanced.

Q2.7-The English lessons with my students
A1: I've had a great time talking with the students because they are fun and easy to talk with. They are always eager to ask questions and give much effort to express themselves.
A2: FUN! Experience with the students.
A3: Very interactive and fun.
A4: Even though they are badly talk in English, they still tried their best to communicate with us and I had fun.
A5: For me, this was the best. Sitting around a table or just talking everywhere every time we see them, I feel so happy. We get to have friends and I think it was the best part.
A6: It was one of the best parts of the classes. I really enjoyed teaching them and helping others speak in English. I love to interact with them, we made lots of friends.

Q3. What do you want to do during your stay in our college next time?

A1: If I will be given another chance to go to next time, I want to be one of the students. I want to stay longer and have more experience and knowledge.
A2: Study here as a student next time.
A3: I WANT TO STUDY HERE.
A4: Maybe in the near future, if I come back again in your college, I want to teach computer related topics and also English. I also want to study here if I have a chance.
A5: I would love to have more time with students and talk with them a lot. Also to attend more classes, and want to visit other famous places but with students as well so it will be much more memorable.
A6: when I visit the college next time, I would love to go visit the local companies inside Osakikamijima. I always wonder (what) how it like is to live and work insight this inland.

Q4. What do you think of living in the dormitory, and on this island?

A1: For the 2 weeks we stayed here, I feel like I would stay here and live here. It's already feels like my hometown. It's been great and memorable.
A2: Awesome, if I have the chance to live in Japan, I choose this inland to stay.
A3: On the dormitory, it has a complete thing, had a clean room, kitchen and bathrooms. And on this island, the people are so kind and polit.
A4: It's so nice and I learned how to become independent even just for 2 weeks. The environment is so peaceful and beautiful.
A5: It was my first time being away from my family. But the dormitory, Wakashio clubhouse has been a home to me. Living together with the students or near them made me see a refreshing view every day. How I love to stay here.
A6: I think this place is very peaceful, convenient and amazing. The island is as pretty as its people and culture. I love the location of our dormitory; everyone is near so they can always come at night to talk.

Q5. What impressed you most during your stay, except the high prices?

A1: The things that impressed me the most are quite a lot, I'm impressed with the culture, the food, education, and the advancement in technology.
A2: The people, their kind hospitable and respectful.
A3: The view of the island, the peaceful and majestic place of this island.

A4: The beautiful scenes of the island and also the kind hospitable Japanese people.
A5: I was impressed by the hospitality and generosity of everyone here. From the students up to president, everyone is nice and humbled, everyone made us feel like family.
A6: What impressed me the most about Japan is the people, everybody is always disciplined and very smart. I love how the people warmly welcomed us and loved us. They are very hospitable, kind, caring and friendly.

Result and discussion for the short-term program

As we can see from the above questionnaire, the good effects of even a short exchange visit of just two weeks are very evident to the participants. These effects may even change the future path of the participants or their future. This can lead to or promote friendly relations and exchanges between partner colleges, even countries.

Since the participants are selected by the sending college as the best students, the arrival of these excellent students also brings a very positive impact on the students at the receiving college. The students at Hiroshima College not only learned different languages and cultures from the short-term exchange students but also made international friends, improved the international atmosphere of the campus, and increased their courage and confidence to go further abroad.

In other words, the short-term academic exchange program is a cost-effective activity for both sending and receiving colleges and should be actively promoted and developed in the long term.

Achievements and Issues

The objective of this short-term exchange program is to enrich the mutual academic relationship between overseas partner colleges and Hiroshima College. As the above results and discussion on the questionnaire survey, the purpose of the short-term exchange program has been achieved.

However, there are both good results and conflicts or misunderstandings in the international exchange activity of different cultures, even if it is short-term.

As you can see from Table 1, Hiroshima College has not always been successful in accepting short-term exchange students, and there have been interruptions (2011, 2015) and decreases in the number of exchange students. Of course, this exchange program in 2020 was stopped due to the COVID-19 pandemic.

We think that there are two main issues: one is the burden of international travel expenses, and the other one is how to deal with the conflicts and contradictions caused by different cultures and customs.

The cost of international exchange between schools in different countries is generally paid by the participants themselves, which is not easy for ordinary families, and it is even more difficult for students from ordinary families in the Philippines. This is the main reason why these short-term exchange programs are sometimes interrupted, or the number of participants decreased.

Regarding the other issues in the international exchange program, such as communication with each other when making plans, and misunderstandings and conflicts in the daily life of short-term exchange students after they come to Japan, such as separating garbage in Japan, keeping the environment clean and quiet, saving energy, making reservations in advance for everything, and following very careful rules, the staff in charge of the international exchange program need to strengthen their communication skills and deal with them with patience, understanding, and tolerance.

Conclusions

We reported the details and transitions of the program of accepting short-term international students, including the daily schedules, the questionnaire survey results, the active learning effects and ripple effects to Japanese students, and also the issues that exist in this program.

Both the questionnaire survey results and the closing remarks clearly showed that the short-term exchange program enriched friendship and understanding between partner colleges, and improved students' international perspective and communication skills, and provided an opportunity for students to further their international careers and that it is worthwhile to continue to promote and persevere with this program.

For the issue of the international travel expenses for short-term exchange students, we need to actively apply for relevant financial support. JST's (Japan Science and Technology Agency) Sakura Science Exchange Program provides us with a good opportunity and is worth applying for.

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TECHNICAL WRITING CURRICULUM INCLUDING PAIR WORK BY DOCUMENT EXCHANGE FOR FOSTERING SOFTWARE DOCUMENTATION SKILL

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Abstract

In system development, along with the developing process, development documents are written in each process. In each process, developers receive documents as input, develop things based on the documents, and deliver documents as output. Due to the fact that the documents play a role in communication completely, the documents must be written in technical writing. For students who learn information technology, it is important that they not only learn programming, but also technical writing. In our school, students spend a lot of time learning programming. On the other hand, students do not have much chance to write development documents. Therefore, I want students to find out that they need writing skills, that their current writing skills are not enough, and that they need to improve their writing skills. To this end, I created a writing skill curriculum that consists of introduction exercises, skill building drills, and application exercises. In the introduction stage, I want students to discern the role of documentation, what their own writing skills are, and what writing skills are needed. So, I gave students two exercises to do that required them to communicate using documents in pairs. In this exercise, at first, each person in the pairs writes a document by different input, then they exchange documents. Next, they work according to the received document. Finally, they present the result of their work, and they discuss the results and the communication. After that, in the skill building stage, I want students to increase their skills in effective writing skills. I made drills about report writing. This is because students have many chances to write reports about experiments and assignments. At last, in the application stage, as an application of technical writing, students have pair work using the same format as the introduction stage about software developing. The writing theme changes from description writing to requesting programming, and the response changes from maps or figures to program codes. By using pair work during the introduction and application stages, students can get reactions and responses from each other. So, students can understand their current writing skills and they can discern that they must learn technical writing through reaction and response directly. In this paper, I will introduce pair work as an activity during the introduction and application stages. I discuss the results that showed students could understand the goals of each stage.

Keywords: *Technical Writing, Software Documentation, Programming Education, Pair Work, Writing Skill*

Introduction

In system development, along with the developing process, development documents are written in each process. In each process, developers receive documents as input, develop things based on the documents and deliver documents as output. For students who learn information technology, it is important that they not only learn programming, but also technical writing. Therefore, I want students to find out that they need writing skills, that their current writing skills are not enough, and that they need to improve their writing skills. I therefore created a writing skill curriculum that consists of introduction exercises, skill building drills, and application exercises.

In the introduction part, I want students to discern the role of documentation, what their own writing skills are, and what writing skills are needed. So, I gave students two exercises to do that required them to communicate using documents in pairs (Fujita, 2019). This exercise includes four steps: writing, exchange, response, and discussion. At the end of the introduction stage, students have group work that require discussions about the characteristics of suitable writing for communication (Fujita, 2020).

After that, in the skill building stage, I want students to increase their effective writing skills. I made skill building drills about report writing.

At last, in the application stage, as an application of technical writing, students have pair work with the same format as the introduction stage about software developing. The writing theme changes from description writing to requesting programming, and the response changes from maps or figures to program codes (Fujita, 2018).

By using pair work during the introduction and application stages, students can get reactions and responses from each other. So, students can understand their current writing skills and they can discern that they must learn technical writing through reaction and response directly. In this paper, I will introduce pair work during the introduction and application stages. I discuss the results that showed students could understand the goals of each stage.

Curriculum

For students at Nagano Kosen, I developed a curriculum with three steps: These steps being (1) introduction exercise, (2) skill building drill, and (3) application exercise.

(1) Introduction exercise: As a first step, I provide an introduction exercise for this stage of the curriculum. As a goal of this step, students discern the roles of documentation, their own writing skills, and writing skills they need. Another goal is to provide motivation for the next skill-building step drills. By understanding that they need writing skills, I want them to be motivated for studying practical writing skills.

For an increase in motivation, I set up group work after the exercise. I want students to identify their needed concrete writing skills through group work. Therefore, after the first exercise, I instruct students to write down "What characteristics are needed to communicate with documents" on sticky notes. Next, students made groups with 4-5 members, and they shared the sticky notes. They coordinate structure about writing skills using the KJ method using sticky notes.

By participating in group work, I expect students to understand their needed writing skills by sharing sticky notes provided by other students (Fujita, 2020).

(2) Skill building drill: For learning practical writing skills, I provide writing skill building drills about report writing. The reason for setting a skill building drill theme to report writing is due to the environment of report writing in the school curriculum. Though I want students to learn software documentation, students do not have so much time to write documents for software design. On the other hand, students have a lot of time to write reports about experiments and class assignments. Therefore, I want students to learn writing skills in common with software documentation and report writing.

When I developed the skill building drills for writing, I referred to the System Developing Document Quality Model provided by ASDoQ (ASDoQ, 2018). Though the model is built for system developing documents, the model includes common characteristics with technical writing. The reason for using the model for developing the skill building drills is that the model provides specific issues for each characteristic.

(3) Application exercise: In the last step, I want students to have experiments of communication in software development. In the software development process, engineers develop software documents as deliverables. The documents play important roles because engineers will develop things based on documents. When engineers write documents, they must develop ideas for the process, and they must write documents correctly. About the former, it needs design skills and experience for each process. The latter depends on technical writing skills. Therefore, I set a target on the latter one, and I expect students to understand that they need writing skills for software development as engineers, and that they increase motivation to learn writing skills continuously through experiences of communicating with documents.

I use the same pair work format that was used in the introduction exercise stage for this stage.

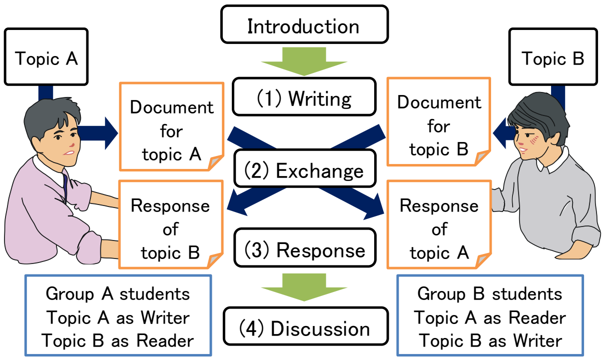

Figure 1 Pair work steps

Pair Work

I created a pair work format that consists of writing documents, exchanging documents, activities of response, and discussion in pairs. The structure of these steps is shown in Figure 1.

(1) Writing: At the writing step, each person in a pair writes documents to request activities with the documents. The topic of writing is different for each person in the pair, topic A and topic B.

The documents are written for requesting any activity that includes drawing a figure, navigation on a map, or requesting programming as some examples.

There are two writing styles at this stage, handwriting and typing. In the case of handwriting, students write on handout paper or some distributed paper. In the case of typing, students type on a template file or a scratch file. I specify the writing style by theme.

(2) Exchange: After writing documents, each person in each pair exchanges documents with the other person. Therefore, each person receives a document written about another topic.

(3) Response: After receiving documents, each person makes a response according to the received documents. The response activity is different in theme and topic.

The examples of responses are, drawn figure, traced map, and programmed code.

When students finish the response activity, they show the response to the other person. If the response is on paper, they hand the paper to the other student. If the response is by typing, they show the results by computer monitor to the other student.

(4) Discussion: After showing the response to their partner, they have a discussion in pairs.

Table 1 Discussion Sheet for Description Writing

Position	Memo
As a reader	
As a writer	
Etc.	

Table 2 Discussion Sheet for Programing Writing

Position	Target	Memo
Programmer	Program	
	Document	
Designer	Program	
	Document	
Etc.		

I prepared a discussion sheet for taking notes about discussion. The discussion sheet has many columns. For the introduction exercise, there are three columns about their position, “as writer” and “as reader” for description, and “etc.” (Table 1). For the application exercise, the discussion sheet has two categories, positions and targets, where positions are “as programmer” and “as designer”, and targets are “about program” and “about document” (Table 2).

The reason why I prepare a discussion sheet is so that they play the two roles of writer and reader in pair work. I want students to discuss with different positions. So, I expect students to think about the discussion topic from each position using the discussion sheet.

Exercise theme

I apply the pair work format to the introduction step and the application step. I prepare exercise themes for each step.

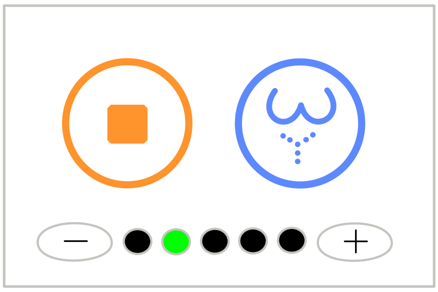

Figure 2 TopicA picture for space order exercise

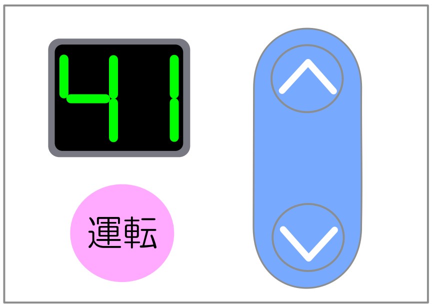

Figure 3 TopicB picture for space order exercise

(1) Description writing: At the introduction step, the goal is that students discern their current writing skills, that they realize they need writing skills, and that they are motivated for studying practical writing skills in the skill building step.

For achieving these aims, I prepare a description writing exercise without special techniques. A special technique would be programming or designing, for example. If introduction exercises need special techniques, students cannot focus on communication using documents.

Descriptions are classified by space order and time order (Sammori, 2013). I made exercises referencing the description writing categories.

(1-a) Space order: A space order is a method of arranging information spatially that presents information from large to small, from entirety to partial.

As a writing exercise about space order, I prepared two pictures. In order to transfer information to each other, students construct the structure of the object in the picture, and they write down the description in Japanese language.

The picture images are made based on control panels from a toilet shower and a bath boiler. A reason for selecting this design as input is that control panels can be a user interface as software design. In the introduction step, the theme is not necessary to relate to software design. But I want to set a theme that relates to software design if possible.

One person from each pair tries using Figure 2, and the other tries using Figure 3. Each person in the pair write descriptions on paper about the other picture. After writing the description, they exchange the paper, and they draw the figure referenced by the description in the received document.

(1-b) Time order: A time order is a method of arranging information in the order of time, that generally presents information from oldest to newest.

As a writing exercise about time order, I prepare a map (Figure 4). There are two types of maps that can be written about different destinations from a common station. Therefore, they write the description about load navigations from the station to each destination.

After writing the navigation descriptions, they exchange the descriptions. They trace routes on a plain map along with navigation descriptions on the received document. They then mark the arrival point on the map.

(2) Program Writing: For the application exercise, I prepared a writing exercise about programming.

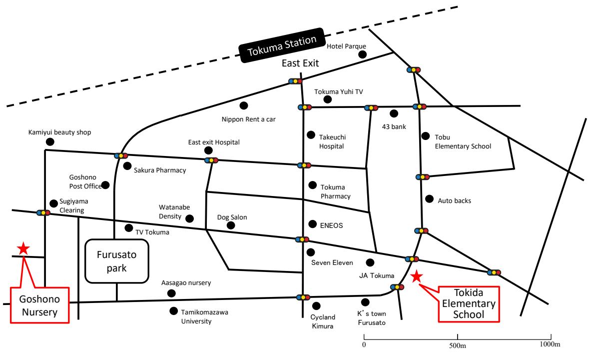

Figure 4 Navigation map for time order exercise

Generally, developing along with the developing process, developers reference the input documents to develop things, and then write the results on output documents. When the developer develops each process, the developer needs two kinds of skills. One is design skills for the process, and the other is writing skills to write down the result of the design on documents.

In this curriculum, I set the target of writing skill to the exclusion of design skills. To try design skill, knowledge is needed about the process, engineering technique, etc. Because I want students to discern about communication using documents in this step, I prepare exercises for focusing on communication by documentation. I prepare two exercises for pair work.

(2-a) Ranking: One exercise theme is about ranking. I hand out a paper that has this algorithm written on it, using examples (Figure 5) for one person of each pair.

The exercise has scores of two subjects for five people, and it requires a ranking with the subject score. The ranking algorithm has the following steps. (1) Set rank number "1" for all people initially. (2) Pick one person from them all, and set it as a basis. (3) Compare the basis score and the others. If the other score is less than or equal to the basis, increase the rank number by 1. (4) Change the basis to another person, then try step (3) until all people have been the basis. After these steps are finished, the rank number shows the rank of each person.

I think students know this sort of algorithm already from other class subjects in the school curriculum. But they do not know the particular ranking algorithm very often. So, I expect students to learn this ranking algorithm for the first time.

One person from each pair receives the paper that shows this algorithm with an example. I ask one person from

Initial State

Subject	1st	2nd	3rd	4th	5th
Japanese	68	81	83	90	65
Mathematics	92	76	51	85	69
Sum	160	157	134	175	134
Rank	1	1	1	1	1

Set 1st person as basis, compare 1st person with others

Subject	1st	2nd	3rd	4th	5th
Japanese	68	81	83	90	65
Mathematics	92	76	51	85	69
Sum	(Basis)160	(Small) 157	(Small) 134	(Large)175	(Small) 134
Rank	1	1+1	1+1	1	1+1

Set 2nd person as basis, compare 2nd person with others

Subject	1st	2nd	3rd	4th	5th
Japanese	68	81	83	90	65
Mathematics	92	76	51	85	69
Sum	(Large)160	(Basis)157	(Small) 134	(Large)175	(Small) 134
Rank	1	2	2+1	1	2+1

Set 3rd person as basis, compare 3rd person with others

Subject	1st	2nd	3rd	4th	5th
Japanese	68	81	(Basis)83	90	(Small) 65
Mathematics	92	76	51	85	69
Sum	(Large)160	(Large)157	(Basis)134	(Large)175	(Same)134
Rank	1	2	3	1	3+1

Set 4th person as basis, compare 4th person with others

Subject	1st	2nd	3rd	4th	5th
Japanese	68	81	83	90	65
Mathematics	92	76	51	85	69
Sum	(Small) 160	(Small) 157	(Small) 134	(Basis)175	(Small) 134
Rank	1+1	2+1	3+1	1	4+1

Set 5th person as basis, compare 5th person with others

Subject	1st	2nd	3rd	4th	5th
Japanese	68	81	83	90	65
Mathematics	92	76	51	85	69
Sum	(Large)160	(Large)157	(Large)134	(Large)175	(Basis)134
Rank	2	3	4	1	5

Figure 5 Algorithm about Ranking

each pair to write a description about this algorithm on a template file of Microsoft Word.

(2-b) Linear Programming: Another exercise theme is about Linear Programming. I hand out a paper that has this type of algorithm with an example (Figure 6).

The exercise has an amount of money students can use along with the price of two goods (potato chips and candy). It requires students to figure out the proper amount of goods they can buy in order to leave the least amount of change. The algorithm has the following steps. (1) Set potato chips quantity lowest 0, calculate money left for purchase 0 potato chips. (2) Set candy quantity to be able to purchase candy with full money left, calculate money left over after candy purchase. It will be the change. (3) Increase quantity of potato chips, recalculate from step (2) until the quantity of potato chips is full. (4) Select the least change pattern from all the patterns.

The important point is that the answers are given from all the patterns.

The other person in each pair receives the paper that shows this algorithm with an example. I ask one person from the pairs to write a description about this algorithm on a template file of Microsoft Word.

Results

The following is a summary of the results of pair work.

(1) Response Result: After the introduction stage, the following results were gathered by questionnaire.

The result of the question: "How does the response result about button design differ from what you expected?" is shown in Figure 7, "How does the response result about load navigation differ from expected?" is shown in Figure 8, "How does the response result about programming differ from expected?" is shown in Figure 9.

In Figure 7, the percentage of "Same" and "Near" is 40%. On the other hand, in Figure 8, the percentage of "Same" and "Near" is 96%.

In Figure 9, the percentage of "Same" and "Near" is 64%. The percentage of "Same" "Near", and "Slightly different" are close, at about 30% for each.

Price Definition

Goods Name	Price
Potato Chips	¥130
Candy	¥50

Steps

Sample case about by 420yen

	Potato Chips	→	Candy	→	Change
(1)	Quantity: 0 Price: ¥0	Money Left ¥420	Quantity: 8 Price: ¥400	Money Left ¥20	¥20
↓					
(2)	Quantity: 1 Price: ¥130	Money Left ¥290	Quantity: 5 Price: ¥250	Money Left ¥40	¥40
↓					
(3)	Quantity: 2 Price: ¥260	Money Left ¥160	Quantity: 3 Price: ¥150	Money Left ¥10	¥10
↓					
(4)	Quantity: 3 Price: ¥390	Money Left ¥30	Quantity: 0 Price: ¥ 0	Money Left ¥30	¥30

Figure 6 Algorithm about Linear Programming

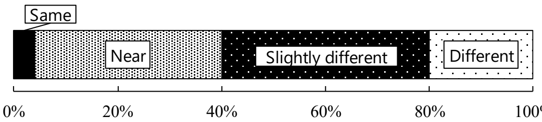

Figure 7 How does the response result about button design differ from expected

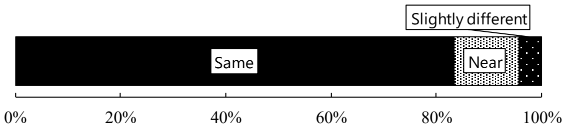

Figure 8 How does the response result about load navigation differ from expected

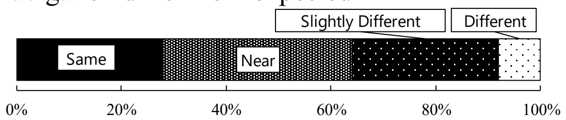

Figure 9 How does the response result about programming differ from expected

(2) Discussion Sheet: Next, discussion sheets were evaluated about the effects of pair work. In this pair work, students played the roles of both writer and reader.

The first evaluation for the discussion sheet is for the role of writer. I classified discussion sentences by the classes, "Self", "Other", "Response", and "Reflection". The "Self" is a class that means the sentence is about one's own writing. The "Other" class means the sentence is about the communication partner. The "Response" class means a sentence is about the response output. The "Reflection" class means a sentence that reflects the student's own abilities during the task. By classifying in these ways, I wanted to analyse what percentage of each type of sentence was occurring through pair work.

Before counting and classifying, I separated single sentences from different memos written in the field of the writer position on discussion sheets. The result of this classification is shown in Table 3.

The second evaluation for the discussion sheet is by the role of reader. I classified discussion sentences by the classes, "Construe," "Structure," "Description," and "Communication." The "Construe" class means a sentence written about construing the meaning of the received document. The "Structure" class means a sentence written about the structure of the document or information. The "Description" class means a sentence written about description and expression in documents. The "Communication" class means a sentence written about communication using the documents.

Table 3 Classification of sentence as writer on discussion sheet

Class	Exercise theme		
	Space order	Time order	Programing
Self	65	38	32
Other	15	8	4
Response	9	6	20
Reflection	0	1	5

When students read the other person's document as a reader, they have already written documents as a writer. So, the hope is that students will think about the goal of communication from both positions of the writer and reader.

Before classifying, I separated memo sentences written in the memo field of the readers on the discussion sheets. The result of classification is shown in Table 4.

Discussion

I will discuss the exercise theme and effect of pair work by examining the results of the questionnaires and the discussion sheets.

(1) Response Result: The results of the responses about the button design description writing showed that the percentage of "Same" is lowest. About the cause of this result, the given pictures are difficult to explain perfectly. However, I don't expect perfect responses. It is not necessary to be the same as the given image. It is enough if the appearance or shape, and structure is close to the given image. This is because in the limited time, the overall situation is the most immediate priority, and details are only secondarily treated. So, the result, "Near" and "Slightly different" are about 80%, which is not bad.

On the other hand, the results of the load navigation description writing showed that the percentage of "Same" is over 80%. This result suggests that the load navigation theme doesn't give a huge variety of results. In the load navigation description, many descriptions are written in an ordered list. A writer could write navigation descriptions step by step using numbers, directions, and landmarks. By expressing themselves in concrete terms, readers could trace the correct load, and arrive at the given goal point. In this situation, there are no ambiguous expressions and little room for interpretation.

Regarding the application exercise, "Same", "Near", and "Slightly different" have similar percentages. The application exercise includes elements of both space order and time order. The documents were written in multiple paragraphs or ordered lists. The paragraph descriptions have the descriptions, "firstly," "secondly," and "at last," to represent order of sequences. The results suggest that the programmer could understand the overall processing.

(2) Effect of Pair work: I will discuss the effect of pair work from the position of both the writer and reader.

(2-a) As a writer: I will discuss about sentences from the writer position on the discussion sheet. About

Table 4 Classification of sentence as reader on discussion sheet

Class	Exercise theme		
	Space order	Time order	Programing
Construe	33	11	39
Structure	12	16	11
Description	21	13	4
Communication	8	5	4

classification, the effect from the pair work is more depth in this order: “Self” < “Other” < “Response” < “Reflection”.

The sentences of the “Self” and “Other” class can occur without pair work. However, the sentences of the “Other” class include content about the other person of a pair or a common communication partner. In this pair work, the writer can set the other person of the pair as the target reader, therefore this activity can accelerate thinking about a communication partner.

The sentences of the “Response” and “Reflection” classes occur with the response materials. The sentences of the “Response” class included content that express the difficulty of communicating information and the wrong or right responses of the documents. The sentences of the “Reflection” class included content that express feedback about their own writing like, “I should have done ...”.

However, the sentences of the “Response” and “Reflection” classes are not so numerous. Therefore, a facilitator should encourage students to observe responses adequately, and then think about what should be done based on the responses in discussion time.

(2-b) As a reader: I will discuss about sentences from the reader position on the discussion sheet. The sentences of the “Construe” class included simple impressions from the received documents. The sentences of the “Structure” and “Description” classes include writing technique. Examples from “Structure” include “present a comprehensive first”, “priority”, and “detail needs” while examples about “Description” include “unification”, “ambiguous representation” and “listing representation”.

The sentences of the “Communication” class include meta impressions from the received document. Examples about “Communication” include “difference between reader and writer”, “Number representation is too concrete to understand directly” and “required time with and without description of algorithm”.

As a reader, they detect that they need writing technique. Also, they find out about the importance of communication. This impression is a meta result in this exercise. When they read a received document, they have written another document already. Therefore, they can find some writing techniques or communication impressions by reading a document. However, “Communication” classified sentences are not so numerous. So, it is necessary to facilitate the opportunities to realize comprehensive impressions.

Therefore, students can discover the writing technique that they need, and this exercise will be an introduction for the next skill building drill or constant skill building.

Conclusions

In system developing, developing documents are written. For students who study information technology, technical writing skills are needed. I provide a technical writing skill curriculum that includes introduction exercises, skill building drills, and application exercises. I use pair work for the introduction and application exercise stages.

The pair work has a common format where students in each pair write a document on different topics, exchange the document with their partner, work with the received document, and discuss the response result as well as their communication.

By using a discussion sheet, students can play the roles of both writer and reader. As a writer, they can recognize their own skills by themselves, and as a reader they can recognize what they construe through reading documents, and they can think about writing elements: structure and descriptions. But through these activities, students mention the important elements of reflection and communication very little.

By the analysis of the above, I must improve discussion facilitation. Regarding the discussion results from the writer position, I must encourage students to think about “what should I do” as a writer. As a reader, students played the roles of writer and reader. I want students to find comprehensive impressions and not only writing techniques.

Acknowledgements

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BLENDED MODE EDUCATION IN INTERNATIONALISATION – A CASE STUDY OF THE VTC GLOBALITES PROGRAMME

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Abstract

In the current arena of vocational and professional education and training (VPET), there has been an increasing emphasis in internationalisation in which students are encouraged to engage in learning activities that contain international elements in both industry/professional and general studies.

However, the COVID-19 pandemic has changed how learning activities are conducted and students' opportunities in participating in cross-border physical exchanges have been severely restricted. Overseas visits. study tours and semester-based exchanges have generally been ground to a stop, meaning that students have been unable to take part in these learning activities which would broaden their horizons and expanding their knowledge of the world. With outbound learning activities being limited, the implementation of local-based programmes with international elements would become important to ensure that the emphasis in internationalisation is not being reduced.

This paper studies the VTC Globalites programme, a structured experiential learning programme for students in the Vocational Training Council (VTC), Hong Kong, which is delivered in a blended mode, i.e. both online and onsite. This general studies programme, which targets students across various academic disciplines and levels within the VTC and is co-curricular in nature, enables students to continue having exposure to the global arena through different types of activities and programmes across different platforms. These activities include onsite talks and seminars, online lectures and trainings, virtual exchanges with overseas students and professionals, self-initiated studies and personal reflections of learning experiences. This would give the students an all-round learning experience to expand their horizons and form exchanges with fellow students from around the world. The programme is also designed to be reward-based which awards students for their participation, with the hope to increase their motivation in engaging in activities within the programme. The programme's receptiveness among students, its effectiveness and possibilities for improvement, especially when situations go back to normal in the future and physical cross-border exchanges can resume, are also discussed in the paper.

Keywords: *Blended mode of learning, international studies, vocational education and training*

Introduction

As the world becomes more connected, there has been an increased trend of internationalisation across all facets of education. While some has held the view that vocational and professional education and training (VPET) is very much a competency-based training and its nature contradicts the notion of internationalisation in scope, time focus, location, complexity and driving force (McKay, 2004). However, the notion of increasing the emphasis on developing VPET programmes that prepare students for global prospects has long been proposed. Smith and Smith (1999) were of the view that it is important to provide VPET students "the opportunity to learn and experience cross-national and cross-cultural understanding and skills to enable their effective participation in an increasingly globalised world" and to "develop international networks". They have also identified the role technology plays in internationalisation. With increasing movement of people and knowledge across the world, young people nowadays also need to be prepared to work in an interconnected world and be proficient in the skills required in diverse, multicultural workplaces (Stone, et al., 2014).

Internationalisation has long been an active element at the Hong Kong Vocational Training Council (VTC). Staff and students have long had experiences in many activities in the field of internationalisation. These include cross-border short visits, overseas study tours, and participation in international events. In the 3 academic years between 2016/17 and 2018/19, there has been a total of 1,091 activities organised, with a total of 28,355 students participating in them.

However, the COVID-19 pandemic has changed drastically on how learning activities are conducted. It has also severely impacted students' opportunities in participating in cross-border physical exchanges. Student exchange activities, both inbound and outbound, have ground to a stop. Activities that were planned must be postponed, with most of them eventually cancelled. Face-to-face instructions were suspended, and lessons were forced to move online. For a practice-centric education such as VPET, this has proved to be a huge challenge, as some study reflected that students considered online learning has not provided better experience and productivity in mastering competencies (Syauqi, Munadi, & Triyono, 2020). With the absence of an outbound experience, which is a key element of an education in internationalisation and cannot be replicated in an online environment, locally conducted learning activities with international elements have become more important, to ensure that students' exposure and knowledge in internationalisation are not being reduced, or at least being reduced to a lesser extent.

The VTC Globalites Programme

The VTC Globalites Programme has its roots in the International Student Ambassadors (ISA) Programme. The ISA programme was initially established in 2014 to provide VTC students with opportunities in engaging and interacting with overseas visitors to the VTC. Students in the ISA programme were often engaged as ambassadors or assistants to international events organised by the VTC, such as the WorldSkills Hong Kong Competition in 2017 and the International Symposium on Advances in Technology Education in 2018. While the programme has enabled students to interact with international visitors, the effect of the programme was deemed to be limited in nature, as only a small number of students would benefit from each exposure. Also, the students were engaged only on an event basis, meaning that if there is no event happening, they would not have the chance to be engaged. This was what happened in the COVID-19 pandemic, in which all incoming visits and large-scale international events were put to a stop.

In view of this, a proposal to restructure the ISA programme was made in September 2020, i.e. the beginning of the 2020/21 academic year. The new programme, called VTC Globalites, was designed to allow flexibility for students to develop and be engaged in international activities, as well as to encourage students to develop a global mindset and awareness even in non-structured environments. Instead of just engaging students to assist in international events or meet international guests, students are now given the freedom to take part in or even initiate activities where elements of internationalisation are present. There are four dimensions of activities in the VTC Globalites, with various objectives in each dimension:

Event Participation: Students are required to take up different roles in international or international-themed events of different scales. These roles can be student ambassadors, masters of ceremony, exhibition booth presenters or simply as participants. Training activities that train students' readiness in event ambassadors, inter-cultural awareness and communications are also considered.

Event Organisation: Students may form teams to organise activities and events with an international theme and put into use the lessons and experiences gained in their participation of events. Students will be given guidance and assistance in their course of organising the activities.

Personal Journaling: We believe it is important for students to record their own learning experience after participating in these activities, and through personal journaling, students are to contribute and share the lessons they have learned in the activities that they have participated in or have organised. These journals would provide a record of their learning and may also be something that can be shared with other students. At the end of the term, these journals will be compiled as an annual, and be produced at the year-end recognition ceremony.

Globalites Study Tour: To complete the entire experience, this annual study tour to an overseas country would allow students to gain a deeper and understanding of a foreign country.

To encourage students to actively participate and organise in activities, as well as recording their learning experience through personal journaling, the VTC Globalites programme adopts an award system which students earn points for their participation. The accumulation of points would qualify students for awards of different levels, namely bronze, silver and gold. With the exception of the Globalites Study Tour, participation in each activity of the other three dimensions would earn students such points. We consider it desirable that students be able to earn as many points as possible and qualify for the highest awards, therefore the students may participate in activities that may be organised by other departments or faculties within VTC, or even by organisations outside of VTC. The participation in these activities will be counted as long as they contain significant elements of internationalisation. In this way, we are encouraging students to participate in activities that appeal to them most, to ensure that their learning experience be enhanced. Also, students would not be limited to just taking part in activities that are co-curricular in nature but would also be encouraged to actively participate in activities that may be more related to their courses of study, thus enhancing their overall learning experience on internationalisation.

Launching of the Programme

When the VTC Globalites idea was conceptualised, it was planned with a hybrid structure in mind. While the COVID-19 pandemic was part of the reasons to the concept of the VTC Globalites programme, we also believe that the learning of internationalisation – which in its own nature can be co-curricular that complements the students' learning in their own specialised fields – does not have to be restricted to a physical format, as there are many opportunities for students to learn about the world in different settings. Some of the learning can be conducted in an organised manner in physical settings, such as in a classroom, a field trip or industrial attachments, while some can be conducted over the Internet, either via videoconferencing, viewing of online materials and reflecting on the relevant learning experience. As such, the VTC Globalites programme is one that combine both online and onsite elements, and the volatile nature in the containment of the COVID-19 pandemic inadvertently provided the programme a good ground for execution. When the pandemic situation was more serious, activities were mainly conducted online. When it became better and social distancing restrictions were relaxed, some learning activities would then be conducted onsite.

During the first 6 months of the programme, there has been a total of 7 activities organised for students, with 3 of them conducted onsite, and the other 4 online. The activities that have been organised are summarised in Table 1 below.

Table 1: List of VTC Globalites Activities between November 2020 to April 2021

Activity	Nature	Purpose
Dining Etiquette Training (November 2020)	Onsite	Allowed students to learn international standards of dining etiquette
High Table Dinner and VTC Globalites Appointment Ceremony (November 2020)	Onsite	Provided students with real practice on their dining etiquette training
Self-learning Exercise: Cross-cultural Review (December 2020)	Online	Allowed students to learn the cultures of different countries through presentations by the consuls general which are recorded and produced by a local public broadcaster
Webinar on Understanding Cultural Diversity (January 2021)	Online	Allowed students to understand some fundamentals in dealing with cultural differences
Webinar on Organising Cultural Activities (February 2021)	Online	Gave guidance to students on how they could organise activities with respect to different cultures
Webinar on Public Speaking and Emceeing (March 2021)	Online	Trained students to become masters of ceremonies and give presentations in different cultural settings
Outdoor Activity: Cycling Trip (April 2021)	Onsite	Provided students with the opportunity to meet and interact with non-local and exchange students at the VTC

The variety of learning activities organised in the VTC Globalites programme have allowed students to gain a wide spectrum of co-curricular knowledge, which can supplement to those being learned in the students' actual academic programme. In normal times when travelling is possible, students could have participated in outbound study tours or could meet visiting academics, professionals or fellow students in activities in Hong Kong. With these being impossible during this period, such activities that are conducted in a blended mode have enabled our students to continue receiving important international experiences that are beneficial to their development.

Student Participation in the VTC Globalites Programme

75 students were admitted into the 2020/2021 cohort of the VTC Globalites Programme, of which 28 were progressing students who were previously on the ISA programme, and the other 46 being newly admitted. These students are from various levels of programmes at different VTC member institutions, with the majority enrolled in Higher Diploma and Degree programmes. Table 2 shows the composition of the initial batch of VTC Globalites.

Table 2: Composition of Students Enrolled in the 2020/2021 Cohort of VTC Globalites

Study Level	No. of Students	Percentage
Degree	33	44%
Higher Diploma	38	51%
Diploma & below	4	5%
Total	75	100%

In terms of activities, there has generally been a fair participation rate among the students. While students are generally encouraged to participate in all the activities that are being planned for them, they can take part only in those which they are interested in or are available for. Table 3 is a tabulation of the participation rate for the 7 activities that have been organised between November 2020 to April 2021.

Table 3: Student Participation in VTC Globalites Activities

Activity	Participants	Percentage
Dining Etiquette Training	29	39%
High Table Dinner and VTC Globalites Appointment Ceremony	51	68%
Outdoor Activity: Cycling Trip	9	12%
Webinar on Understanding Cultural Diversity	22	29%
Webinar on Organising Cultural Activities	26	35%
Webinar on Public Speaking and Emceeing	26	35%
Self-learning Exercise: Cross-cultural Review	13	17%

Students' feedback on the activities were collected through the personal journals, in which their opinion on the activities, their reflections and evaluations were collected in a written format. Students are generally encouraged to record these journals to show that they have undergone a thinking and learning process after the activities, which also allowed us to have an insight into their thoughts towards this process, as well as the opinions on the conduct of the activities. By the end of April 2021, a total of 14 journals have been received from the students and they are generally positive.

Some students described the VTC Globalites programme to be a "wonderful platform for VTC students to explore new perspectives of multiculturalism, it provides us various opportunities for international information and insights" and "fosters people's understanding and respect for each other". Others have indicated that participating in the VTC Globalites programme has allowed them to "step out of their comfort zones". Through their participation in activities to be "wonderful chance(s) to improve" and become "more confident". Many have also indicated that they have "become more aware of cultural differences" and "meet people without offending them".

Experience Gained and Suggestions for Follow-up Studies

Due to the pandemic-incited restrictions on gatherings, suspension on face-to-face instructions in schools and institutions, there would have been a lot of challenges if learning elements within the VTC Globalites programme were designed to be completely onsite. However, the pandemic, while undesirable in nature, has actually provided opportunities for the programme, and as a new co-curricular programme, much of VTC Gloablites' initial few months have been highly experimental in nature as we aim to find out the right balance of online and onsite activities for the participants. With the experience we have gathered so far, we have gotten the some perspectives which will be useful for our future planning of the programme, not just during the ongoing pandemic, but also when situations go back to normal and on-site learning can be conducted again.

Deciding the mode of delivery for different learning experiences: Some previous studies seemed to suggest that students in general do not prefer online delivery of learning programmes (Price, Richardson, & Jelfs, 2007; Paechter & Maier, 2010), and while additional study research could be done, some feedback from students in the programme seems to suggest that online delivery of learning experiences may be something that students are happy to receive as well. For example, in the webinar on public speaking and emceeing, of the 20 students who returned the evaluation questionnaire, 17 have shown agreement (including partly agree and strongly agree) that the session, despite being delivered online, has still allowed them to "feel more confident to speak in public after the workshop". One comment from a participant indicated that, while "it does not really help overcome the fear of public speaking", "online practice is less stressful". As such, we consider that the experience gained by the students may not necessarily be completely dependent on the mode of delivery alone, but rather the nature and contents of the learning experience. In fact, Koskela et al have opined that virtual learning environments have been successful in introduction courses (Koskela, Kiltti, Vilpola, & Tervonen, 2005), and in this connection, we believe that some of the activities conducted in the VTC Globalites programme so far, in particular the webinars on understanding cultural diversity and organising cultural activities, which are introductory in nature, can continue to be conducted online in the future. For activities that are not introductory and theoretical in nature, they may be better organised in a physical setting, or a combination of both. For example, the dining etiquette training, because of the need of practising the use of utensils, may be more suitable for a physical training; the public speaking workshop, on the other hand, may cater for both online and onsite training, to allow students to feel less stressful initially by doing the first sessions online, and building them up to facing a real audience subsequently in a physical setting.

Increase channels in receiving feedback towards different learning activities: The original plan was to utilise the personal journals to solicit students' opinions in the activities. To entice students to submit journals, which records their learning experiences in these activities, the award system has a specific requirement on the number of journals that students need to submit for award qualification. However, after the initial period, we have noticed that students' general response to writing the journals is low despite the attraction of the awards, judging by the number of journals that we have received. While it may be due to the students' perception towards the awards, we consider it would be necessary to include an evaluation exercise at the end of each activity in the future to solicit students' feedback and opinion, and with these data we can perform onward analysis on how these learning activities are received, and what we can do in the future to enhance the students' learning experiences.

Post-graduation follow-up: The VTC Globalites programme is developed to provide students the opportunity to learn more about internationalisation and while envisioning it to be useful for students' studies in the VTC, it would also be desirable to find out how much an impact their experiences as VTC Globalites have benefited after they have graduated. As such, it may be a good idea to do follow-up studies with graduates to see if the programme may have contributed positively towards their subsequent endeavours, e.g.in their job-searching process, discharge of their work after being employed, or experience gained in further studies outside of Hong Kong. Results from such follow-up and tracking studies may help us further fine-tune the programmes that we could line up for current students within the programme and continue to deliver activities that fit the needs of the students, as well as meeting our objectives of increasing students' understanding and acceptance towards internationalisation.

Conclusion and Possible Future Research Directions

Because of the COVID-19 pandemic, studies on online delivery of academic programmes would likely to increase in quantity and quality. While it is indeed necessary to examine the impact of the delivery of academic programmes on students, it may also be interesting to see how the co-curricular aspects of education such as personal growth, character building and global mindset development – something that the VTC Globalites programme was designed to fulfil – would be affected. As a newly established programme, VTC Globalites appears to have achieved some small initial results in encouraging students to be more exposed to elements of internationalisation alongside their regular studies, judging by the participation rate and feedback provided by the students. However, we are also aware that the results gathered so far are inconclusive of the programme's real effectiveness. As such, we believe that it is necessary to conduct further studies and research to gauge the real effectiveness of the programme. Some of the work that may be needed would include more accurate and complete documentation of students' feedback and achievements, increasing the pool of students enrolled in the programme and conducting systematic tracking of students' participation. In doing so, we could have a better understanding on how the programme is performing and have more information to make decisions on programme enhancements. These would ensure that the VTC Globalites programme fulfils its original objective of development a global mindset among its participants.

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The efforts of a microbiology experiment using a smartphone microscope

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Abstract

The rapid development of digital technologies has provided many new physical and virtual tools that can be applicable to various educational situations. In particular, the advent of smartphones has enabled teachers to adapt new active learning approaches in education from primary school to college level. Smartphones typically come with a sensitive- and high-resolution camera comparable with ones used in academic and industrial fields. In this report, we present the benefits of the mobile microscopy which converts a smartphone such as iPhone to an easy-to-use microscope. Purposes of introducing mobile microscopy in school experiments are the following. 1) To provide more opportunities to students to experience microscopes so that they can learn how to handle microscopes. 2) By having students make a mobile microscope based on a simple principle by themselves, we aimed to facilitate self-learning of the microscope mechanism. The hand-made mobile microscope was made from a small glass ball (ϕ1.5 ~ 2.5 mm) sandwiched between a pair of thick paper pieces with a hole for the bead positioning. To comp are the capability of the hand-made mobile microscopy we also purchased a commercial one, Leye, recently reported by Dr. Nagayama. Examination of two types of a mobile microscope revealed that magnification obtained with the hand-made one (~ x130-200) is higher than that with Leye (~ x100), suggesting that Leye is more suitable for observing larger planktons such as Volvox and Daphnia, whereas, hand-made one is for smaller specimens like mycelia and spores in mold samples. To evaluate the effects of mobile microscopy, we conducted an online questionnaire and found that 60% of students were satisfied with the microbiological experiments using mobile microscopy. Furthermore, 90% responded that they were able to obtain better understanding of the principle of the monocular microscopy. In summary, we demonstrated that the introduction of mobile microscopy is beneficial to students as well as teachers as a model for active learning.

Keywords: *mobile microscopy, Leye, active learning, microbiology experiment, smartphones*

Introduction

The rapid development of digital technologies has provided many new physical and virtual tools that can be applicable to various educational situations. In particular, the advent of smartphones has enabled teachers to adapt new active learning approaches in education from primary school to college level. Smartphones typically come with a sensitive- and high-resolution camera comparable with ones used in academic and industrial fields.

In microbiology experiments in our department, we teach how to use optical microscopes to observe the morphology of microorganisms for identification and classification. However, the number of optical microscopes we own is not enough for about 40 students, making it difficult for students to fully experience how to use microscopies, therefore causing the insufficient understanding of the microscope mechanism.

In this report, we present the benefits of the mobile microscopy which can quickly convert a smartphone such as an iPhone and Android device into a user-friendly microscope in a few steps. Our porpuses here are the following. 1) To provide more opportunities to students to experience microscopes so that they can learn how to handle microscopes. 2) To let students make a mobile microscope based on a simple principle by themselves, we aimed to facilitate self-learning of the microscope mechanism. The mobile microscope, Leye, desgined by Dr Nagayama(need references) (Institute of Physiology, Japan), is made from a small plate with a small glass ball positioned in the centrer fo the plate. Ley is placed over the front camera of smartphone, allowing the smartphone to function as an optical microscope. In additon, we asked students to make their own mobile microscopes which consisis of a glass ball, black thick papers, and a double-sided tape. After the experiments, we conducted an online questionnaire to evaluate if students were able to understand the principle of optical microscopy. The results showed that more than 90% of

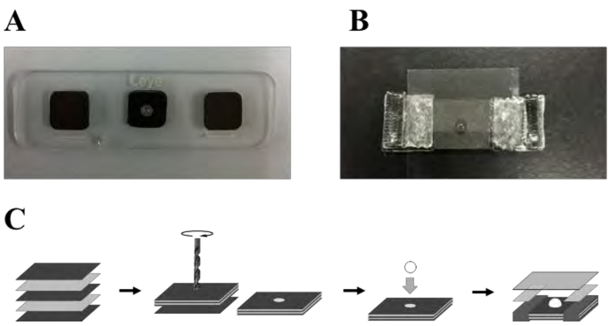

Figure 1. Mobile microscope Leye and the making own mobile microscope. A) Leye. The lens is in the center circle. The black square next to lens is a magnet to hold the smartphone. B) Making own mobile microscope. The lens is in the center circle. Place a piece of cover glass on top of the glass ball. C) Handmade microscopy instruction. Firstly, three pieces of black paper are placed together. Secondly, use a drill to make a hole at the center. Thirdly, embed a glass ball in the hole. Finally, place and stick the cover glass on top of it.

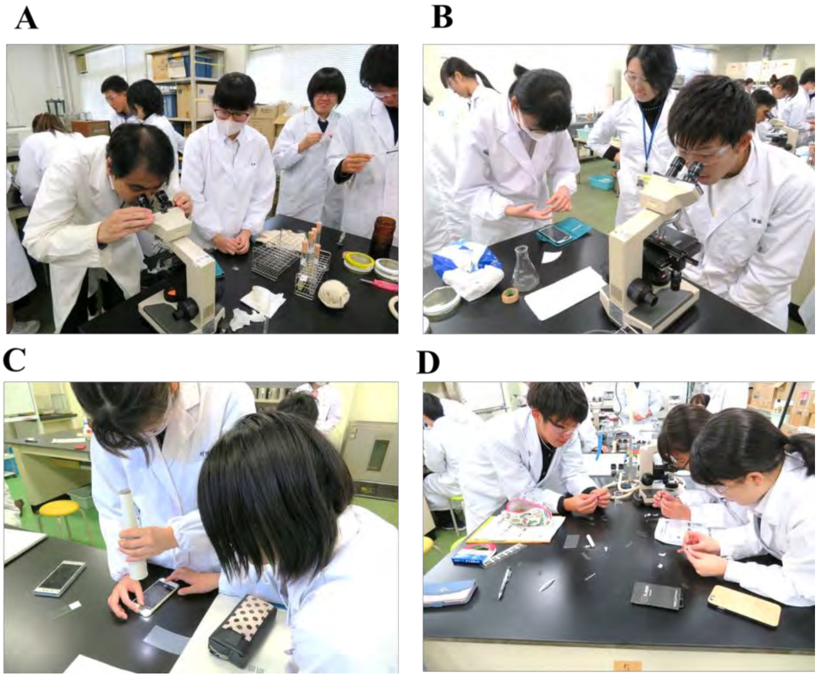

Figure 2. Pictures of the students using various optical microscopes. A) Observations using a conventional optical microscope. A teacher checks a sample to confirm the focus. B) Observation using a conventional microscope and Leye. A student on the right is using a conventional microscope, while a student on the left is placing a sample on Leye. C) Observation of a sample using Leye. Students are working together to photograph samples. By illuminating with a pocket light above Leye, clear images can be obtained. D) Making a glass ball microscope. Students are reading the protocol and helping each other to make their glass ball microscopes.

the students answered that they could understand the principle and more than 70% were satisfied with the experiments. Thus, the introduction of the mobile microscopy is one of effective projects to enhance self-learning.

Materials and Methods

Target group

44 students at third-grade of the Department of Chemical and Biological Engineering at National Institute of Technology, Ube College, participated in the experiments.

Mobile microscope “Leye”

Leye (figure 1A) was purchased from an online shop, amazon.co.jp. Leye is 20 x 65 mm^2 in size and has a magnification lens in its center. A black square magnet adjacent to the lens holds Leye on the smartphone. Leye was placed on the front camera of a smartphone and samples were put on Leye. For observation, a pocket light was used as an illuminator.

A handmade glass ball microscope

Glass balls GB-2 (figure 1B) were purchased from Kenis (Japan). Three layers of black carboard (0.75 mm thickness) was trimmed into 12 x 12 mm^2 size square. A 1-mm^2 hole was made in the center of the square piece with a needle. A glass ball was fit into the hole on which a coverslip (18 x 18 mm^2) was placed. The cover glass was attached to the black board by cellophane tape. The observation method was the same as Leye.

Observed samples

Samples used to evaluate the capability of the mobile microscopes included silkwarm lavae, Daphnia, slipper

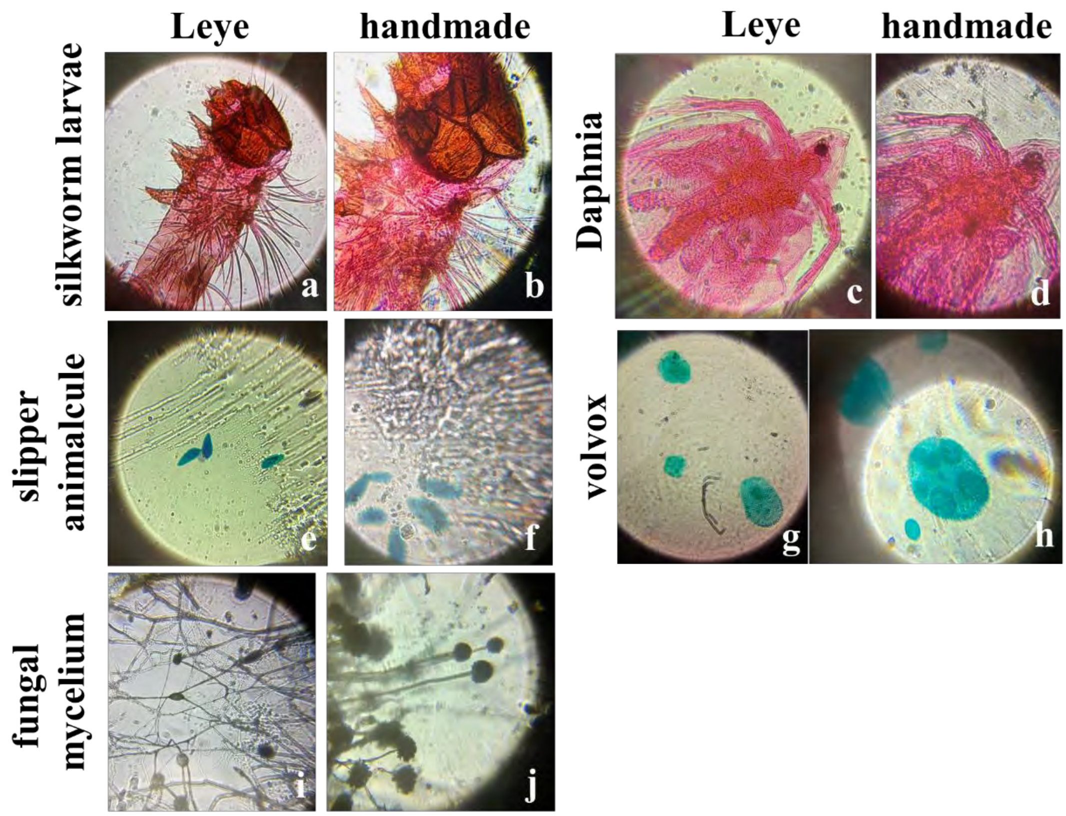

Figure 3. Morphological observation of samples using mobile microscopes. a, c, e, g and i) Images taken with Leye. b, d, f, h and j) Images taken with a handmade glass ball microscope. a and b) Images of silkworm larvae. Every single hair is clearly visible. c and d) Daphnia magna. e and f) slipper animalcule. The unicellular organism slipper animalcule can also be observed. g and h) Observational images of volvox. i and j) Observational images of fungal mycelium. Note that the mycelium and spores of the molds could be observed with Leye and a glass ball microscopes.

animalcule, Volvox, and fungal mycelium.

Questionnaire survey

After the experiment, students were asked to answer an online questionnaire about their experiences of the mobile microscopy. The five questions were the followings:

Q1: Did you understand how to use an optical microscope correctly?

Q2: Were you satisfied with the experiment using the optical microscope?

Q3: Were you satisfied with the experiments using the Leye?

Q4. Were you satisfied with the experiment using the handmade mobile microscope?

Q5. Did you make your mobile microscope and understand the principle of monocular microscopy?

Results and Discussion

Microbiology experiments using a mobile microscope

To help students understand the principles of optical microscopy, we introduced mobile microscopes in addition to a conventional optical microscope in microbiology experiment. Students chose their favourite samples and observed them (Figure 2). We explained the principle of optical microscopy and taught them how to handle Leye (Figure 2A and 2B-C). The students were given the protocol to make their own handmade glass ball microscopes (Figure 2D). For observation, the students needed to cooperate with each other: one for taking images, the other for illumination. The image quality was substantially affected by the brightness and the illumination angle.

The students were able to think and proceed their experiments based on their own ideas, which made us thought that active learning education had been put into practice.

The photographs of the samples taken by the students are shown in Figure 3. The samples includes silkworm larvae (Fig. 3a, b), daphnia magna (Fig. 3c, d), slipper animalcule (Fig. 3e, f), Volvox (Fig. 3g, h) and moulds (Fig. 3i, j). Clear images were obtained both by Leye and the handmade mobile microscope. The different sizes of the images is attributed to differences of the camera perforce on students' smartphones

Questionnaire of experiments using mobile microscopes

At the end of the experiment, a questionnaire was given to the students about their experiments with the mobile

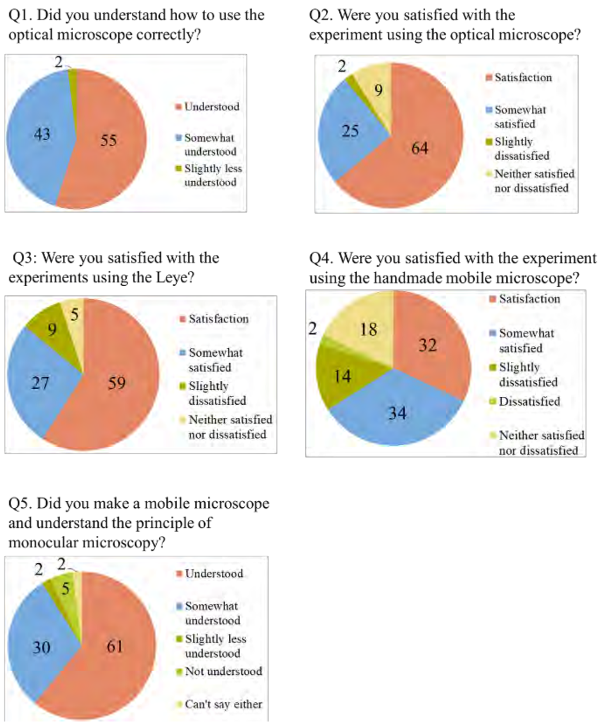

Figure 4. Questionnaire survey of the experiments using mobile microscopes. Q1) 55% of students said they understood it, 43% said they generally understood it and 2% said they did not understand it well. Q2) 64% of the students were "satisfied", 25% were "somewhat satisfied", 2% were "not very satisfied" and 9% were "neither satisfied nor dissatisfied". Q3) In the experiment using Leye, 59% of the students were "satisfied", 27% were "somewhat satisfied", 9% were "not very satisfied" and 5% were "neither satisfied nor dissatisfied". Q4) In the experiment with the glass ball microscope, 32% of the students were "satisfied", 34% were "somewhat satisfied", 14% were "not very satisfied", 2% were "not satisfied" and 18% were "neither satisfied nor dissatisfied". Q5) In the experiment with the glass ball microscope, 61% of the students understood the principle of the monocular microscope, 30% understood it to some extent, 2% did not understand it very well, 5% did not understand it and 2% were undecided.

microscope. The results are shown in Figure 4. 98% of the students answered that they understood how to use an optical microscope correctly, suggesting that teachers have provided a proper instruction on how to use the microscope. 89% were also satisfied with the experiments using the optical microscopes. 86% of the students were satisfied with the experiments with Leye. Those who not satisfied said that there were differences in the image resolution among smartphone models such as Android devise and iPhone, and that they found that it was difficult to adjust brightness and focus properly. Indeed, the resolution varies depending on the front camera resolution. Students using camera with less pixel numbers were not able to capture clear images. 7% of the students did not understand the principle of optical microscopy. To solve this problem more person-to person training in addition to a group learning will be necessary in the future. 64% of students answered that they were satisfied with the experiments using the glass ball microscope. However, the satisfaction level was lower than that of Leye. The possible reasons for this are: 1) students who are good at doing a craft were able to obtain good images, while students who are not good at it were not, and 2) handling the handmade glass ball microscope is more difficult than ready-to-use products such as Leye is. The questionnaire survey showed that the students were generally satisfied with the experiments using the mobile microscope. Many students left positive comments on the mobile microscope experiment, saying that they could become familiar with microorganisms by turning their smartphones into microscopes.

Conclusions

The conclusion of this experiment is that the use of mobile microscopes has helped students develop an interest in microbiology experiments. Many students were able to think by themselves to take images with better quality than others, for example by using a different light source. Introduction of mobile microscopy can provide a good oppotunity as an active learning. It is also a prime example that incorporates the ICT into basic biology education.

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Engineering Education Initiative by Making an Accelerator with Collaborating Nearby Laboratories

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Abstract

We are building a system for KOSEN students with the aim of learning through the practice of making particle accelerators. That is, we prepare for a Project-Based Learning (PBL) of "let's make an accelerator in KOSEN". It is very difficult for students to make an accelerator only with the support of KOSEN teachers and staffs. To solve this difficulty, the cooperation system which is the accelerator outreach named "AxeLatoon" with nearby laboratories, High Energy Accelerator Research Organization (KEK), RIKEN, and so on, was established. We have been manufacturing a prototype accelerator, a miniature cyclotron, in order to identify issues when students make. We also already organized an information session and three seminars. Even under the influence of COVID-19, we established a mechanism to participate remotely using video conference and Learning Management System (LMS) and continue activities. The system we have built, and activities so far are introduced in this paper.

Keywords: *accelerator, active learning, project-based learning, cyclotron, remote, video conference, LMS*

Introduction

The particle accelerator is an equipment that accelerates charged particles by electric force called Lorentz force $\vec{F} = q(\vec{E} + \vec{v} \times \vec{B})$. Accelerators consist of particle sources, high voltage sources, magnets, magnet power supplies, vacuum, beam diagnostics, control system, and more. Many technologies are required, such as mechanics, electromagnetism, processing, control, vacuum, thermodynamics, and materials that contain a wide range of engineering techniques learned by KOSEN students. The practice of making accelerators leads KOSEN students to deeper engineering learning so the accelerator can be said to a good education tool for KOSEN students. Furthermore, fostering cooperation can be expected because better cooperation between different major students is necessary to make up for each other's lack of knowledge for making an accelerator. We also expect that knowing accelerators, which are used in various fields, such as science, industry, and medicine, will be a career education because it is an opportunity to think about the future. We have been preparing in order to realize a Project-Based Learning of "let's make an accelerator in KOSEN" with collaborating nearby laboratories since 2020.

This paper is organized into five sections. The next section introduces the collaboration with nearby laboratories. The third section describes fabrication of prototype accelerator. The fourth section presents activities for students, information session and seminars. The result, discussion and conclusions of this paper are presented at the final section.

Regional Cooperation System

It is very difficult for KOSEN students to make an accelerator only with the support of KOSEN teachers and staffs. This difficulty can be solved by collaborating nearby laboratories.

The accelerator outreach named "AxeLatoon" (https://www2.kek.jp/axltn/) with nearby laboratories, High Energy Accelerator Research Organization (KEK), RIKEN, and so on was established. This outreach aims for everyone to know accelerators. There are three main activities. First, we make accelerator with KOSEN students according to this initiative. Second, we give workshops where participants can play with accelerators. Finally, we will hold accelerator contests.

We would like to expand this initiative to all KOSEN in Japan and eventually hold a contest. We hold meetings and share information with two communication tools, Zoom and slack, so that accelerator production activities can continue anywhere in Japan even COVID-19, therefore the AxeLatoon members can support KOSEN students.

Prototype Accelerator Fabrication

The main activities were limited to teachers, staffs, and only 5th-grade student engaged as part of Graduation research in Ibaraki KOSEN because the student activities in 2020 were strictly restricted due to COVID-19. That is why instead of student activities we began to make prototype accelerator in order to identify issues when students make for preparation.

The accelerator type of the prototype is a cyclotron, especially called classical cyclotron (Particle Accelerator Society of Japan, 2018). The cyclotron which accelerates charged particle such as proton, heavy ion between two D-shaped electrodes called Dee in static magnetic field was invented by E. O. Lawrence in 1929. Two D-shaped electrodes are connected to AC power supply and generate an electric field between electrode gaps. The accelerated charged particles follow a spiral orbit as shown in Figure 1 (Lawrence, 1934).

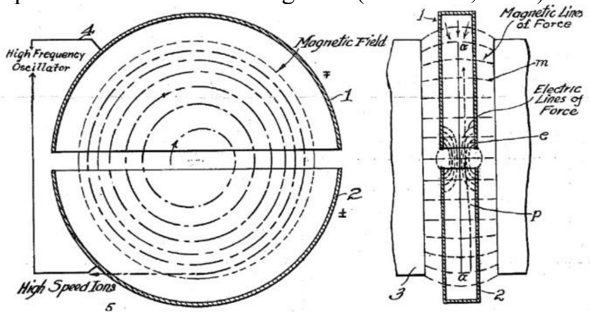

Figure 1 Patent Diagram of Cyclotron by E.O. Lawrence

(i) Design

Before processing a prototype, we need to design the electrodes and vacuum chamber for the Dee. For that purpose, we need two main tools: electromagnetic field calculation and particle tracking, which should be provided to the students in order to be able to design accelerator by themselves. In accelerator research, CST Studio Suite is often used for electromagnetic fields calculations and particles tracking calculations. However, it takes costs, so it is unrealistic to expand the activity to all KOSEN in Japan. Whereas CST Studio Suite Student Edition (https://edu.3ds.com/en/get-software) can be used free of charge for educational purposes only after registration. However, the Student Edition has limited functions, and particle tracking calculations are not available. So, we focused on Geant4, which is used for elementary particle research and radiation education. Geant4 is free and could be used for particle tracking calculations. For solution, we tried to calculate particles tracking by using CST Studio Suite Student Edition and Geant4 with the 5th-grade student.

The procedure was the following. First, electric field generated by the Dee electrode in the vacuum chamber and magnetic field by a dipole magnet were calculated and exported into text data. Next, Using the text data sorted in the order suitable for Geant4 calculations, Geant4 calculated the behaviours of protons in the electromagnetic field environment calculated by CST Studio Suite Student Edition. With this procedure, we confirmed that the orbits could be obtained. However, the handling of Geant4 running under Linux environment is rather complicated for students who are not familiar with Linux environment, especially for younger students. we still need to find another way.

(ii) Processing

The prototype was processed at the Workshop in Ibaraki KOSEN by staffs. Through this processing, there are some of the processes in which students can demonstrate their skills include grooving for the O-ring in the vacuum chamber and predrilling of the chamber cover screws using NC programming as shown in Figure 2. However, it was also found that there were some processes that were difficult to perform using only the skills acquired in regular classes as described below, and therefore, additional training was needed for accelerator production.

Figure 2 Processing using NC programming.

There are some items that are difficult to determine machining conditions such as machining speed for each material and amount of infeed, etc. by the students themselves because they have never handled the material in class.

There are also some processes that are not implemented in the class such as boring for hollowing out of a Dee cup and angle indexing for determining the angle of the hole for the port on the side of the chamber ring, wire cutting, and so on.

In addition, it is necessary to examine to what extent the lack of machining accuracy affects the electric field and the trajectory of electrons.

In this prototype fabrication, the following two point were tried in consideration of students' processing. The Dee was made thicker to allow a margin and used resin-based adhesive instead of welding for joining the chamber ring and ports. As the result of vacuum test, it was confirmed that desired vacuum level 10^ (-2) Pa can be reached even when bonding with resin-based adhesive.

In the end, the solution for students is to do a lot of machining and learn from their mistakes.

(iii) Assembly

We have just assembled it and started the acceleration test as shown in Figure 3. We have been gathering necessary equipment such as vacuum gauges and power supplies borrowed from KEK. In this way, we save on the cost by borrowing from a cooperation research institution.

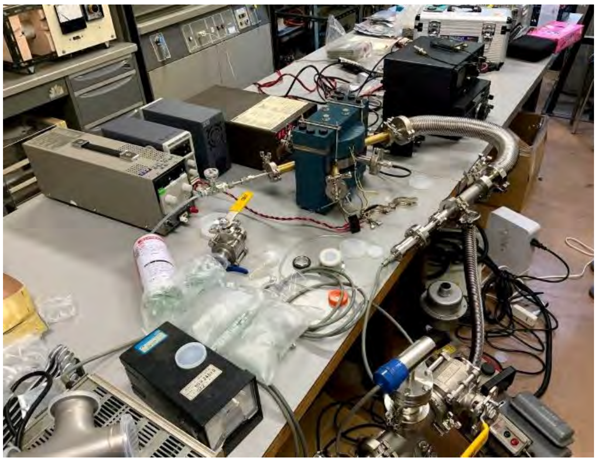

Figure 3 The assembled prototype cyclotron accelerator.

Information Session and Three Seminars

We planned to recruit applicants as an extracurricular activity at the beginning of academic year. In order to inform more students in Ibaraki KOSEN and to familiarize them with accelerators, we held information session and three seminars. We also created a class for this project in Google Classroom, which is Learning Management System students are familiar with, and we have been using mainly for information sharing such as presentation materials and videos.

1) Information Session held on 21st October 2020

Although we only announced the information session once or twice to each of the classes that we were teaching, 31 students participated the information session held on 21st October 2020. At that time, we were able to gather students and hold the information session. As shown in Figure 4, we also used video conference, Zoom, because some talkers who are a little far away participated remotely due to time constraints and so on.

At the information session, after overview of this project, two accelerator types, cyclotron and electrostatic linear accelerators, which we guess we can make in KOSEN, were introduced by the members who are making accelerators at home. The above prototype is based on the one. At the end of the information session, there was an exciting time for questions from speakers to students.

Figure 4 Students were listening to the talk using video conference at the information session.

2) Three Seminars

At the seminar, members of AxeLatoon talked about their research in order to find out what accelerators Japan (and the world) have and how accelerators are used. In addition, we conducted demonstration experiments and practical training on vacuum, magnet, and cyclotron in preparation for students to start manufacturing. The first and second were totally online due to COVID-19. At the third one, we were able to gather students again.

2-1) The first seminar held on 2nd December 2020

The first seminar was held on 2nd December 2020. A lecture on neutron source and neutron imaging for Nagoya University accelerator and a demonstration experiment of vacuum test of a vacuum chamber for the prototype as shown in Figure 5 were done.

2-2) The second seminar held on 13th January 2021

The second seminar was held on 13th January 2021. There were three lectures on J-PARC and iBNCT, muon acceleration, and neutrons utilization created by accelerators. And a demonstration measurement of magnetic flux density at the centre of the dipole magnet were carried out.

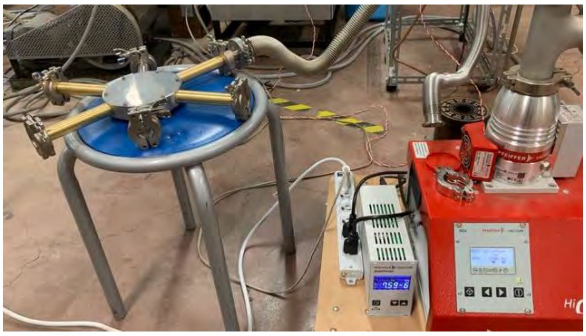

Figure 5 Demonstration experiment of vacuum test of vacuum chamber for prototype.

2-3) The third seminar held on 4th March 2021

The third seminar was held on 4th March 2021. Students were not able to see and operate the equipment directly even if they had already been introduced at previous two seminars because the previous two seminars had been held online. For the third seminar, we decided to let students actually see and operate it. Since 16 students gathered, we first divided them into three groups and each group went around the booths which students can measure magnetic flux density as shown in Figure 6, observe the prototype cyclotron accelerator shown in Figure7, and tour the Workshop. Then, we all got together and had several students close the lid of the vacuum chamber and install it in the magnet. Finally, a vacuum test was conducted.

After that, there were three lectures on the cyclotron in Japan, the first accelerator in Asia, and research and graduate school life of a graduate student studying accelerators who graduated from KOSEN. We kept vacuuming during these lectures as shown in Figure 8, and the vacuum was checked again at the end of the seminar.

Results and Discussion

The variation in the number of participants for each is shown in Figure 9. A decrease in the number of participants in both information session and seminars is apparent. It can be considered that students attended the information session wanted to know about this project, while those who participated in the seminars mainly want to participate in the accelerator production activities after learning about this project. This difference is thought to be reflected in the decrease in the number of participants.

In addition, the remote sessions tended to attract fewer participants. Particularly, there were fewer participants in the second seminar. It is cosidered that one of the reasons for this was the problem with the set-up time. At the first seminar, we needed to delay the start time so that they could go home after class in order to have the students participate from their home. We surveyed available times to participate by Google Classroom and set the start time 17:10, but could not delay it until after all respondents had gone home. The start time of the second seminar had been also set 17:00,

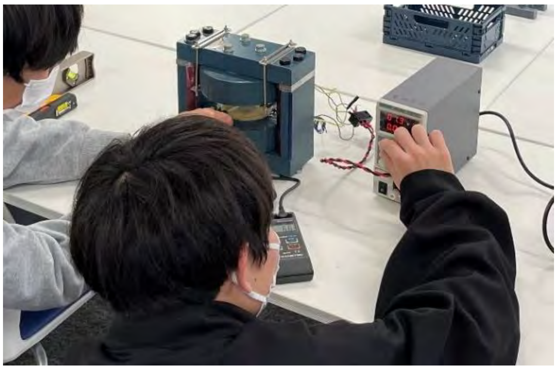

Figure 6 Participated students measured magnetic flux density of a dipole magnet.

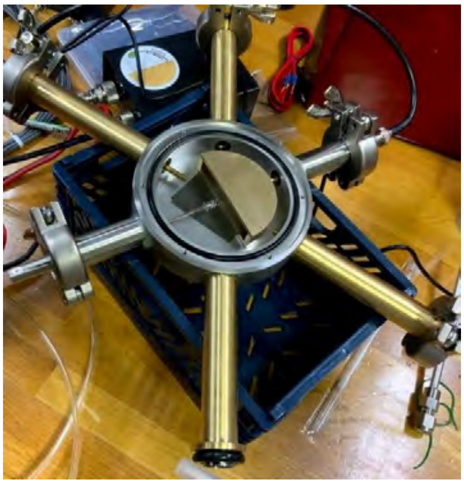

Figure 7 The prototype vacuum chamber and Dee electrode.

Figure 8 The prototype cyclotron accelerator on the left desk was evacuated while students were listening to the lectures.

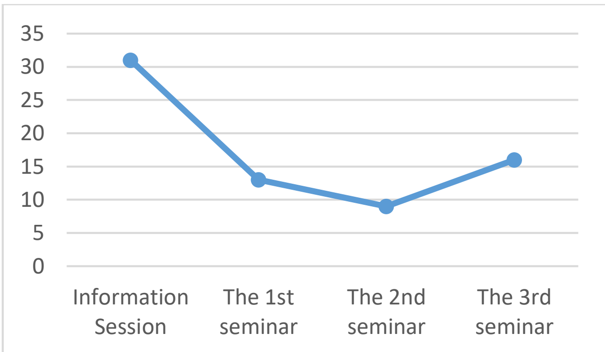

Figure 9 The variation in the number of participants for each.

however the classes were also changed to online due to the impact of the spread of COVID-19 at that time. Although it was no longer necessary to consider the time of go home, the start time was not changed because it was determined that a last minute change would cause confusion. As a result, several students seemed to have forgotten about the seminar due to the time that had elapsed since the end of the class. We consider that these factors contributed to the decline in the number of participants.

After the 3rd seminar, we conducted a questionnaire on Google Classroom registrants, which are 41 students at that time, using Google Form and 17 students answered. We have prepared the following 9 questions, and if they answered "yes" to the 9th question, we have prepared 4 more questions. The content and results of the questionnaire are described below.

1) How did you know this project?

Almost students knew this project from us. Some students were taught by friends and classmates.

2) Did you know Accelerator before participating in this project? (Yes or No)

The result of answering is shown in Figure 10. Less than a quarter of the students had never heard of the accelerator.

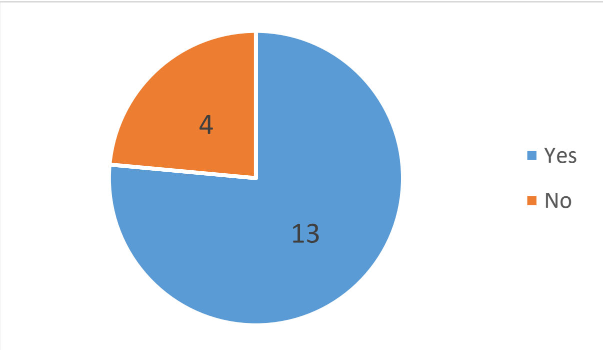

Figure 10 The result of answering the question "Did you know Accelerator before participating in this project?".

3) Which activities did you paticipate in? (including the activities you watched the videos)

The result of answering is shown in Figure 11.

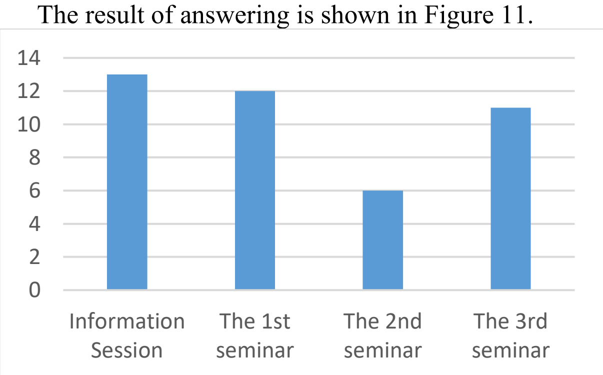

Figure 11 The result of answering the question "Which activities did you paticipate in?".

4) How satisfied you are with the information session and seminars you attended and watched?

The result of answering is shown in Figure 12. When students were asked to rate their level of satisfaction on a 5-point scale, 82% of the students chose the items that corresponded to Very satisfied, Satisfied, or Average, and no student was not satisfied.

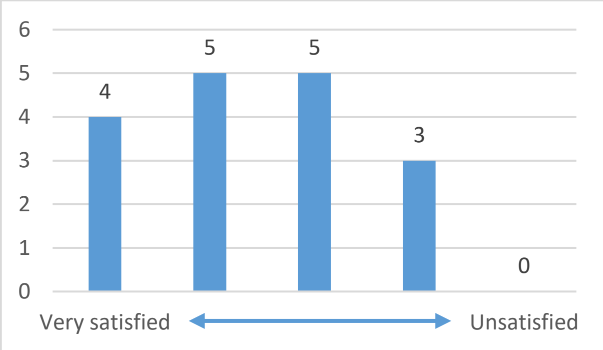

Figure 12 The result of answering the question "How satisfied you are with the information session and seminars you attended and watched?".

5) What was the most intresting part of the information session and seminars and wathced the videos?

Details of the survey results are omitted, but they mentioned specific contents of seminars, talking with experts, and seeing and touching the equipment directly.

6) Please tell us your impressions of participating in the information session and seminars.

Details of the survey results are omitted, but there were many positive comments.

7) Did you read the presentation materials shared in the Google Classroom? (Yes or No)

The result of answering is shown in Figure 13.

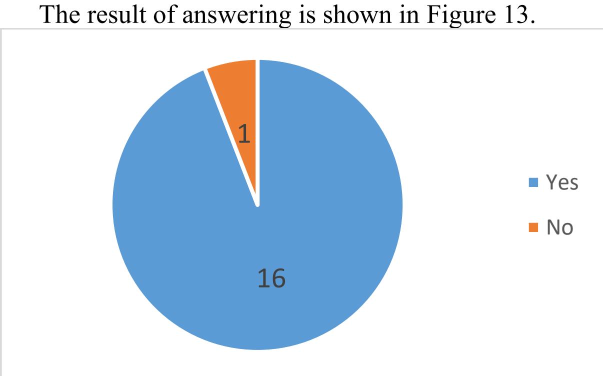

Figure 13 The result of answering the question "Did you read the presentation materials shared in the Google Classroom?".

8) Did you watch the presentaion videos shared in the Google Classroom? (Yes or No)

The result of answering is shown in Figure 14. Based on the results of question 7 and 8, we will continue to use the LMS in our activities.

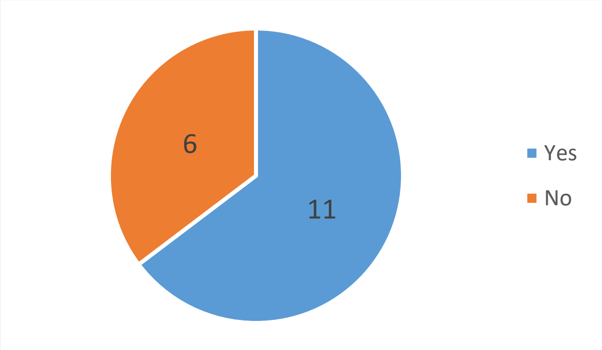

Figure 14 The result of answering the question "Did you watch the presentaion videos shared in the Google Classroom?".

9) Would you like to participate in this project next academic year (after April 2021 to March 2022)? (Yes/ No/ Thinking)

The result of answering is shown in Figure 15.

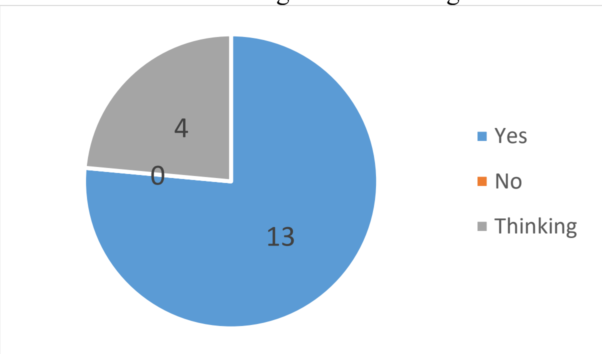

Figure 15 The result of answering the question "Would you like to participate in this project next academic year (after April 2021 to March 2022)?".

10) What do you want to do next academic year? (Multiple answers allowed) (Accelerator Production/ Seminar Participation/ Accelerator tour/ Exhibition, Presentation at conferences/ Watching accelerator-related movies/ Other)

The result of answering is shown in Figure 16.

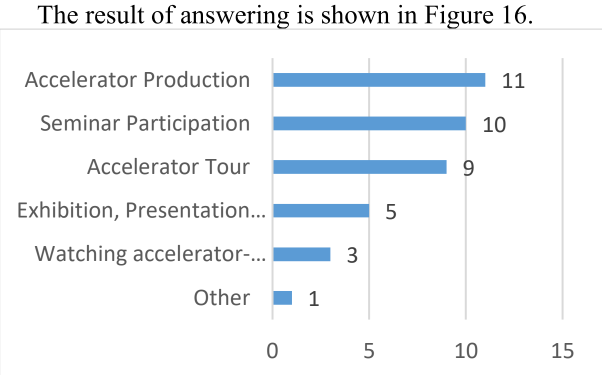

Figure 16 The result of answering the question "What do you want to do next academic year?".

11) What are you interested in the accelerator? Do you find it interesting?

Details of the survey results are omitted, but the opinion that it is high energy was noticeable.

12) What kind of accelerator do you want to make? (Cyclotron Accelerator / Electrostatic Linear Accelerator/ Others)

The result of answering is shown in Figure 17.

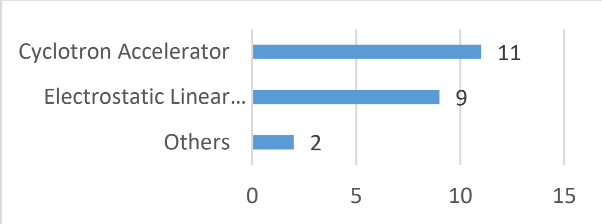

Figure 17 The result of answering the question "What kind of accelerator do you want to make?".

13) What kind of talk would you like to expect at future seminars?

The survey results are omitted. We will consider the content of future seminars in light of the feedback.

Conclusions

Based on the results of qestion 10, three activities are planed and a student group will be formed. The first activity is making acceletators in a student group. The second activity is holding seminars. And the third one is accelerator tour. Even non-group students can participate in the second and third activities if they want. As a result of the information sessions and three seminars described so far, 18 students have announced their paticipation in the student group in the begining of the 2021 academic year. This project is ongoing and we recognize that we are just at the starting line of PBL. We would like to see how the 18 students change through PBL activities in the future.

To establish a model case of accelerator making in KOSEN at Ibaraki KOSEN is the first step. Then, we hope to expand the activity of making accelerators in collaboration with laboratories and so on all over Japan throughout all KOSEN in Japan.

Acknowledgements

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EDUCATIONAL EXCHANGES BETWEEN METROPOLIA UAS AND TOKYO KOSEN FOR ENHANCING INTERNATIONAL PROJECT-BASED LEARNING

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Abstract

Metropolia University of Applied Sciences (Metropolia UAS) and National Institute of Technology, Tokyo College (Tokyo Kosen) have been conducting educational mutual exchanges for many years. Both educational institutions are exchanging students every year, and each faculty staff also interacts and gives intensive lectures to each other. In particular, Metropolia UAS organizes an international ICT Summer School annually in August. Every year hundreds of students all over the world attend the courses with great enthusiasm to enhance their knowledge on different areas of information and communication technology, as well as to expand their personal networks internationally. Professors and specialists from the partner universities and industry are invited to give intensive courses on their preferred topic in the field of engineering or other field supporting engineering education such as communication, natural sciences, math, business, management etc. While the ICT Summer School acts as one practical way to do transnational teachers and students exchange, it also gives excellent opportunities to discuss about enhancing the cooperation between partner schools. The ICT Summer School gives practical and effective environment and opportunities to enhance the educational exchanges especially between Metropolia UAS and Tokyo Kosen. Meanwhile, at Tokyo Kosen, students from Metropolia UAS and Tokyo Kosen have formed a project team together and tackle to social issues or technological issues. These projects named "innovation project" are conducted as an elective subject of both educational institutions and credits are given to participating students since 2018. In this effort, the student team could carry out very practical projects such as project planning and budgeting, implementation methods and evaluations. Through this international project, students could also develop their communication skills and experience cultural exchange. This paper explains the framework of educational mutual exchange between Metropolia UAS and Tokyo Kosen and reports on the efforts and effects of the international practical projects for students.

Keywords: *international mutual exchange, international project-based learning, ICT summer school, innovation project, educational exchange*

Introduction

Transformation from traditional individual-centered learning to collaboration-centered learning based on project-based approach is becoming more popular and important, especially in human resource development of engineers. Promoting and managing team projects has different challenges than personal learning. It means there are challenges not only for students on the learning side, but also for institutions and organizations that provide learning environment and opportunity for the students. In order for learners to tackle actual social issues and/or technological issues as a project and obtain effective learning from the activity, desirable learning frameworks and processes are required to the educational environment.

"Social implementation education" is an educational programs and concepts that have been practiced at Tokyo Kosen since 2012 (College guide Tokyo Kosen 2018), and it has been widely incorporated by other educational institutions nowadays (H. Yagihita 2017, K. Tatemata 2019). The program involves not only prototype development activities such as programming and digital fabrication within a team, but also discovering real and concrete issues existing in actual society or companies, the process of implementation of the prototype product to solve them, and trying to repeat the implementation and getting feedbacks over and over. The concept is attracting attention as an effective pedagogical method for developing engineers who can bring innovation to the society. Social Implementation Education Forum is an annual forum held in March to form an effective educational community where students report their results and achievements from their social implementation project and faculty members discuss effective PBL education, etc. About 50 teams from many Kosen campuses nationwide participate in the forum every year. In addition, a mandatory subject called Social Implementation Project has been newly introduced at Tokyo Kosen into every 4th and 5th grade students' curricula since 2019. Every student participates team project aimed at solving social issues in the subject.

On the other hand, MINNO® Innovation Project is a problem-solving multidisciplinary learning program that has been implemented at Metropolia UAS for more than 10 years (Hero, Laura-Maija 2020). It is a 10 ECTS (European credit transfer system) program implemented in every bachelor students' curricula. Hero (2020) describes that MINNO® is based on the thinking of innovation development and the processes and collaborative networks they require. More than 1,000 innovation projects are carried out annually at Metropolia UAS, and a systematic pedagogical method has been established in collaboration with industry (Metropolia UAS 2021). There are a lot of similarities between the concept of social implementation education practiced at Kosen and the concept of the MINNO innovation project at Metropolia UAS. This concept is being established as an effective and practical pedagogy for developing innovative engineers and leaders.

In parallel with the adoption of such a collaborative-centered learning approach, Metropolia UAS and Tokyo Kosen have developed international exchange for many years (Antti, K Piironen 2013). Table 1 shows a record of exchange activities between the two institutions from 2010 until 2020. The international exchange relationship was begun by accepting each other's students as exchange student. Then, the cooperative relationship has developped not only students exchange programs, but also intensive lectures provided by faculty members from each other's institutions, and deepened the relationship year by year. In 2018, we started international innovation project with exchange students from Metropolia UAS and Japanese students from Tokyo Kosen teaming up together to tackle with problem-solving projects. The experience of working on a project in collaboration with overseas students is valuable and important, especially for Japanese students, and strongly contributes to their motivation. This effort also contributes to improve their language skills, cultural understanding, cooperativeness effectively. Meanwhile, the project activities in collaboration with Japanese students provides Metropolia UAS students with an environment in which they can smoothly start exchange programs and obtain concrete results in a short period of time. Some of Metropolia UAS students reported the results obtained from the innovation project activity at an ICT-related conference in Japan in 2020. This achievement typically supports the educational effectiveness of international project efforts.

This paper shows the overall framework of educational collaboration between Tokyo Kosen and Metropolia UAS, and reports on practical examples of innovation projects in international teams, their processes, and educational outcomes throughout the efforts. Finally, we describe the impact of this educational collaboration on students and figure out the issues that must be overcome in order to further develop the international collaboration.

Outline of Educational Collaboration

The educational collaboration between Tokyo Kosen and Metropolia UAS consists of two initiatives. The first is intensive lectures and ICT summer school courses on specialized subjects that both faculty members conduct at each other's institutions. Each institution held one to three courses each year. Details of the ICT summer course and intensive course are described later.

The other is an exchange program in which each institution accepts three exchange students. In particular, each exchange student from Metropolia UAS teaming up with Japanese Kosen students to work on an innovation project together. That is, three different teams are formed

Table 1: Exchange record of student and faculty exchanges between Tokyo Kosen and Metropolia UAS

year	from Tokyo Kosen to Metropolia UAS		from Metropolia UAS to Tokyo Kosen	
	students	faculty members	students	faculty members
2010		1 (site visit)		1 (site visit)
2011	2	1 (ICT Summer School)	3	
2012	3	1 (ICT Summer School)	3	1
2013	3	1 (ICT Summer School)	3	1
2014	2	1 (ICT Summer School)	3	
2015	2	2 (ICT Summer School)	3	4
2016	2	2 (ICT Summer School)	3	2
2017	5	3 (ICT Summer School) 1 (site visit)	3	2 (site visit) 1 (intensive course, Judge of SIEF)
2018	4	3 (ICT Summer School) 2 (site visit, student guidance)	3	1 (intensive course, Judge of SIEF)
2019	3	3 (ICT Summer School) 1 (site visit, student guidance)	3	1 (intensive course) 1 (intensive course, Judge of SIEF)
2020	Cancel due to COVID-19	3 (Online ICT Summer School)	Cancel due to COVID-19	

* SIEF: Social Implementation Education Forum

each year at Tokyo Kosen to work on different kind of projects. Every team has a faculty advisor from the laboratory in Tokyo Kosen as a mentor to facilitate the project and provide technical advice. In addition, a faculty member from Metropolia UAS will also facilitate all project teams, and hold regular online meetings to receive their progress reports and give some advice. At the start of the innovation project, a faculty member from Metropolia UAS visits Tokyo Kosen to hold a kick-off meeting, and at the end of the project, a final presentation meeting is held to report the results and achievements of each project. The outline of this educational collaboration is shown in Figure 1.

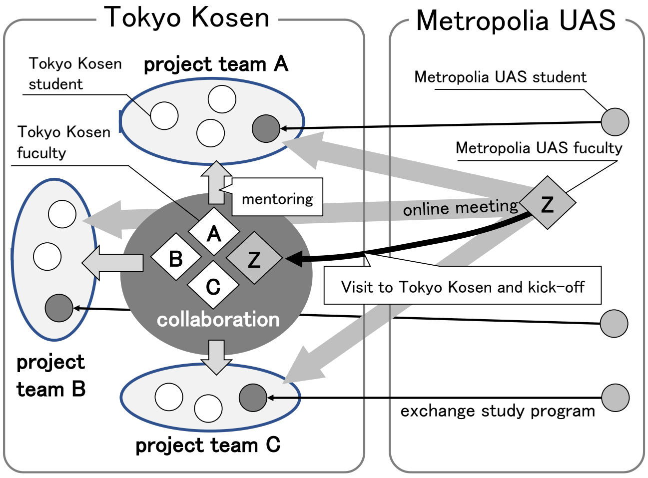

Figure 1: An outline of educational collaboration for innovation project

ICT Summer School and Intensive Course

ICT summer school is held by Metropolia UAS annually in August, with 18 courses in 2017, 15 courses in 2018 and 23 courses in 2019 (Metropolia UAS 2021). Each course is 3 ETCS, and students complete the course by taking a 4-hour lecture a day for 5 days. These courses are not only for Metropolia degree students but also for international students from partner institutions of Metropolia including Tokyo Kosen. Despite the fact that the ICT Summer school 2020 was held fully online due to the spread of COVID-19, 13 courses were carried out and a lot of students participated in the course. As shown in Table 1, a faculty member of Tokyo Kosen held several courses since 2011, and Table 2 shows the course subjects held by them. Figure 2 shows a picture of a lecture on Introduction to Machine Learning course as an example.

This ICT summer school is a valuable environment where teachers can improve their lecture ability by giving classes to overseas students, and it also plays an important role as a community for teachers joining from a lot of institutions all over the world. This community is a good opportunity to make various educational collaborations.

On the other hand, several intensive courses were held by faculty members of Metropolia at Tokyo Kosen since 2017. Table 3 shows the course subjects and Figure 3 shows a picture of a lecture on PSoC Design course at Tokyo Kosen in 2020.

Table 2: The subjects of the courses for the ICT summer school held by faculty members of Tokyo Kosen

subjects	year
Image Processing with MatLab	2011-2019
Introduction to Machine Learning	2017-2020
Introduction to Japanese Language & Culture	2015-2020

Table 3: The subjects of the intensive courses held by faculty members of Metropolia UAS at Tokyo Kosen

subjects	year
Digital Signal Processing	2017, 2018
PSoC Disign	2020
Introduction to Node.js	2019
Introduction to Android Programming	2019

Figure 2: A lecture on “Introduction to Machine Learning course” at ICT Summer School 2017

Figure 3: A lecture of an intensive course “PSoC Design” at Tokyo Kosen

Innovation Project

At Tokyo Kosen, every fifth grades students (19 to 20 years old) and advanced course students (20 to 22 years old) belong to the laboratory, and each is working on their own research topics. Each exchange student from Metropolia UAS belongs to one of the laboratories during the period of the exchange, basically by matching based on their major and interests. They also have some research topics and carry out research activities in the same way as the Tokyo Kosen students. Of course, various technical and cultural exchanges have been a good opportunity and stimulus for both exchange students and Japanese students, however the five-month exchange period is often too short to achieve concrete results from the research activity. In addition to these activities, the educational effect will be further enhanced by setting up new problem-solving projects and introducing a framework for active collaboration between each Metropolia exchange student and Tokyo Kosen students together.

Therefore, international innovation project has been introduced since 2017 during the exchange period. The contents and the pedagogical outline follow of the innovation project are basically inherited from MINNO innovation project at Metropolia UAS. The main difference between international innovation project and MINNO innovation project is that MINNO project topics are authentic challenges from outside of the organization (i.e. real customer such as companies and organizations). Thus, the pedagogical outline for MINNO projects includes a formal infrastructure to communicate and discuss with the real customer.

On the other hand, topics for the international innovation project are more flexible and varied because the topics are basically based on the expertise of the laboratory supervisors. Some projects were conducted in collaboration with real customers, while others were conducted in a more academic research activity. Table 2 shows the project topics which were carried out in 2018 and 2019.

Table 2: Project themes for innovation projects in 2018 and 2019

year	Project theme
2018	A Sports Human Motion Evaluation System for Beginner Level by using Inertial Sensor and Machine Learning
2018	Intelligent Monitoring and Dialogue Agent with AI Speaker and IoT devices for Older Adults
2018	Testing of Self-localization using a High Accuracy GPS and Implementation of its Application System
2019	A Study on Localization and Object Detection System for Mobile Robot
2019	Computer numerical analysis of normal and micro flow
2019	Logistics System Utilizing Reinforcement Learning to Optimize Shipping Costs for Food Welfare Facilities

At the start of the project, a faculty member from Metropolia UAS visits to Tokyo Kosen to hold a kick-off meeting which includes course guidance as well as a lecture on team building and effective video. After that, the projects are carried out with the advice of the supervisor of Tokyo Kosen (Figure 4), and the progress is reported periodically in online meetings with all of the project members and the faculty from Metropolia UAS. At the end of the project, the results of the project will be summarized in a report and presented at final report meeting (Figure 5).

Figure 4: Group meeting with a Metropolia exchange student and Tokyo Kosen students

Figure 5: Final presentation meeting

In addition, several assignments and requirements for final products shown in Table 3 are presented at the beginning of the project. These assignments and requirements serve as a framework for learning the basics of project management such as time management and budget management, and students work together as a team to tackle these assignments. All course materials are provided online, and students submit all assignments and products online.

Table 3 Assignments and final products for international innovation project

Assignments
* 3min project introduction video presentation
* Time table for task management
* Budget planning
* Group meetings (making agenda and minutes)
Final products
* Video demonstration
* Project report

Educational Effectiveness and Future Work

Kosen students have very few opportunities to interact with overseas students in their daily school life, and a lot of them find it difficult to communicate in English. Providing students with a framework for project-based collaborative activities on the occasion of the stay of exchange students from Metropolia UAS is very effective in promoting more active communication among students. Their language skills and international understanding can be developed efficiently by increasing opportunities to use English naturally in project-based activities.

Meanwhile, exchange students from Metropolia UAS want to have technological and cultural exchange opportunities as much as possible in a limited period of time. At this point, although we have only experienced six projects in two years, it is clear that the introduction of project-based education brings closer interaction among students. As a typical example, one of the exchange students achieved concrete results from his project activity, wrote a paper with the help of team members, and reported it at a Japanese academic ICT conference (N. Haapalainen 2020). This is a typical outcome from the project activity and clearly demonstrates the educational effects of project-based learning. Promoting these exchange activities and establishing a framework for developing student initiatives will enhance the effectiveness of future education.

The students who participated in the projects have studied similar technological areas and have a lot of technical knowledge and skills in common with each other. Nevertheless, practical differences found out such as technical tools and development processes in the projects, and there were a lot to learn not only for the students but also for the faculty members from the differences. In addition, practical management skills such as task management and budget management are very important for carrying out projects steadily in real organization. Meanwhile developing students' technical skills and theoretical understandings are extremely important in Kosen education, it is also important to develop practical skills such as project management as well as prototyping skills for social implementation.

On the other hand, topic selection and topic decision process are also important point in project activities. In this time, the student teams tackled their own topic guided by the expertise of the supervisors from Tokyo Kosen. One further idea is to set up a framework for awareness of the relationship between the project topic and global issues such as SDGs. However, in order to facilitate a project that incorporates more global issues, faculty members are required to have the educational skills to approach not only technical issues but also global social issues. For this point of view, it is necessary to strengthen educational capabilities with a global social perspective throughout the educational organization.

Conclusions

Metropolia UAS and Tokyo Kosen have been conducting and developing educational mutual exchanges for many years. As part of the educational collaboration, several courses at ICT summer school of Metropolia UAS and intensive lectures at Tokyo Kosen were conducted by each other's faculties. The courses not only motivate students to learn, but also strengthen the community among faculty members, and they are good opportunities to make an environment for new collaboration.

On the other hand, exchange students from Metropolia UAS and students from Tokyo Kosen have formed a project team together at Tokyo Kosen and tackle to social and/or technical issues. These projects called international innovation project are conducted as an elective subject since 2018, and the participants carry out practical projects while learning project management skills such as project planning and budgeting as well as technical skills. Through this international project, students could also develop their communication skills and experience cultural exchange.

This paper explained the entire outline of educational collaboration between Metropolia UAS and Tokyo Kosen and discussed the effects of the practical projects for students and issues to be overcome. We will continue to strengthen the educational collaboration between two institutions, and at the same time, we plan to explore new forms of educational collaboration in light of the accelerating trend toward online and digitalization in recent years due to COVID-19.

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SURVEY AND DEVELOPMENT OF THE TEACHING TOOL TO EDUCATE PROGRAMMING THINKING AND COMPUTATIONAL THINKING

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Abstract

Our research has concluded that the teaching of computational thinking (hereafter CT) in Japanese programming courses is lacking compared to foreign counterparts. In Japan, programming education has been compulsory since the last year, the class of 2020. In this country, the government is arranging laptops for elementary and junior high schools in a hurry. Also, Japan uses programming thinking as an original educational keyword, instead of CT. Due to the lack of know-how, its teaching tools have many problems. One of these is a difference in the number of teaching tools according to the target age. Therefore, the prime cause of the problems is unclear. Similarly, the type of tool that suits Japan is also unclear. Here we show that our simple teaching tool software easily fixes the fundamental issue, lack of understanding. We compared teaching tools made in Japan and overseas countries. As a result, we found two shortages. One is to make wide the goal. Programming thinking is narrower than CT. Most of it is related to coding. The other one is a teaching tool that answers the goal. Many Japanese teaching tools tend to attract children than answer the goal. Therefore, many people misunderstand the true goal of this education. These shortages can be summarized into a lack of understanding. Our teaching tool is based on the problem. It guides students to learn CT and programming thinking. If students chose activity options on the tool, it teaches students more CT-like selections. Also, it introduces them tools or teaching materials useful to carry out their choices. The software design is very simple so that students can focus, but stylish using Kivy. Our tool was evaluated by students from twelve to fifteen years old. As a result, its natural and simple teaching is praised. We've seen students exhibit greater literacy of information as well as a deeper understanding of computational thinking, the act of thinking about problems the way a programmer would.

Keywords: *Computational Thinking, programming, Teaching, Junior, Software.*

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Introduction

Programming education in Japan aims to develop a student's computational thinking (e.g., MEXT, 2017). According to the Ministry of Education, Culture, Sports, Science, and Technology, programming education is a method to nurture a student's information literacy (e.g., MEXT, 2017).

Our teaching materials advertise themselves as "programming lessons" only as an extension of nurturing information literacy. While there are courses for teaching information literacy (e.g., Benesse Corporation, 2021), little attention is given to programming-exclusive courses. MEXT's list of Information Teaching materials list many products that are called "gadgets" or "tangible" (e.g., MEXT, 2020). Gadgets and Tangible methods are often used for teaching algorithm design (e.g., Robot start, 2021).

In foreign programming courses, the goal is to raise a student's skill at CT (e.g., Wing, 2015). For example, the subject content in English junior high schools states that students will understand a number of important algorithms that reflect computational thinking. CT comes from Wing's championing of thinking like a computer scientist (e.g., Wing, 2015). CT includes the four core components that make it up (decomposition, pattern recognition, abstraction, and algorithm design), as well as the addition of programming and all use of computers (e.g., Morioka, 2017). The general flow of utilizing CT is collecting data, analyzing data, finding patterns, decomposing problems, abstracting, building models, and developing algorithms (e.g., Ignite My Future in School, 2021).

Teaching materials have been prepared for both coding courses and CT courses (e.g., Common Sense Education and Jones, 2021). The majority are robots or applications made for smartphones and tablets, with many teaching languages as well (e.g., Kodable, 2019).

Given the above, this research aims to develop teaching materials that achieve the following three goals:

(1) Require no experience with coding or programmer logic from teachers.
(2) Be highly versatile, usable by teachers even outside of the field of information processing.
(3) Deepen students' understanding of information literacy, CT, and programmer logic.

Materials and Methods

This research aimed to develop a Group Learning Support Tool (hereafter referred to as Tool) as a teaching material targeting students in 11 to 15 years old. This is because in modern Japan, not much time is dedicated to teaching programmer logic to the higher primary education grades. A general outline of the Tool is summarized by the attached flowchart (Figure 1).

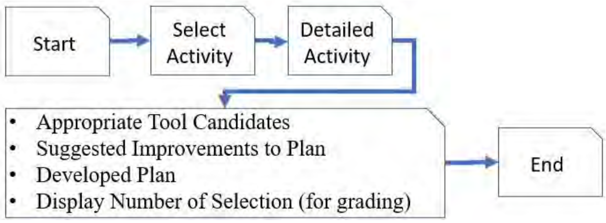

Figure 1 A general outline of the tool

The following table summarizes what teaching materials are related to which subject a student wishes to study next (Table 1). The options reference the ideals of CT (e.g., Ignite My Future in School, 2021). The tool supports two simultaneous selections for secondary education goals. "Num" refers to a serial number, and "Has CT" shows whether it contains the ideals of CT with "Y" or "N."

Table 1 Teaching materials led to from selections

Selection Groups		Num	Has CT	Teaching Materials
	Study, Discover, Research	1	-	
	Creation	2	-	
Study, Discover, Research	Model Creation	3	Y	Tinker CAD, Thingiverse, 3D Printer
Study, Discover, Research	Run Simulations	4	Y	CSUnplugged, Google for Education, Thingiverse, TinkerCAD, Wemogee, Wolfram Computational Knowledge -Engine, Scratch
Study, Discover, Research	Visualize Data	5	Y	Data.gov
Create	Improve	6	N	
Create	Gather Data	7	Y	Poll Everywhere, Internet, Wearable Devices
Create	Ask a Teacher	8	N	
Study, Discover, Research	Analysis	9	Y	Excel
Study, Discover, Research	Visualization	10	Y	
Study, Discover, Research	Read a book	11	N	
Create	Recognizing Patterns	12	Y	The UCL Machine Learning Repository
Create	Organizing Data	13	Y	
Create	Experiment	14	Y	
Create	Create	15	N	
Create	Consider the steps to create	16	Y	Flowchart
Create	Plan	17	N	
Are you confident you can do it on your own?	Yes	18	Y	
	No	19	N	
Can you continue if the plan changes?	Yes	20	Y	
	No	21	N	

The tool our research has developed introduces teaching materials to match the selected education goals. Empty cells indicate that Japan has few representative teaching materials that correspond to the selections. The teaching materials were prototyped in App Builder. For serious development, a Python GUI library known as Kivy was used (e.g., Kivy.org, 2021). App Builder is a no-code platform, making it easy to visualize the tool. However, App Builder displays advertisements and is an entirely online tool, making it lacking in usability. As such, the tool was ported to Kivy, a multi-platform framework that is usable offline. The following images show the specific screen transitions we developed with

Kivy (Figure 2). The chart shows how the screen changes with each choice selected.

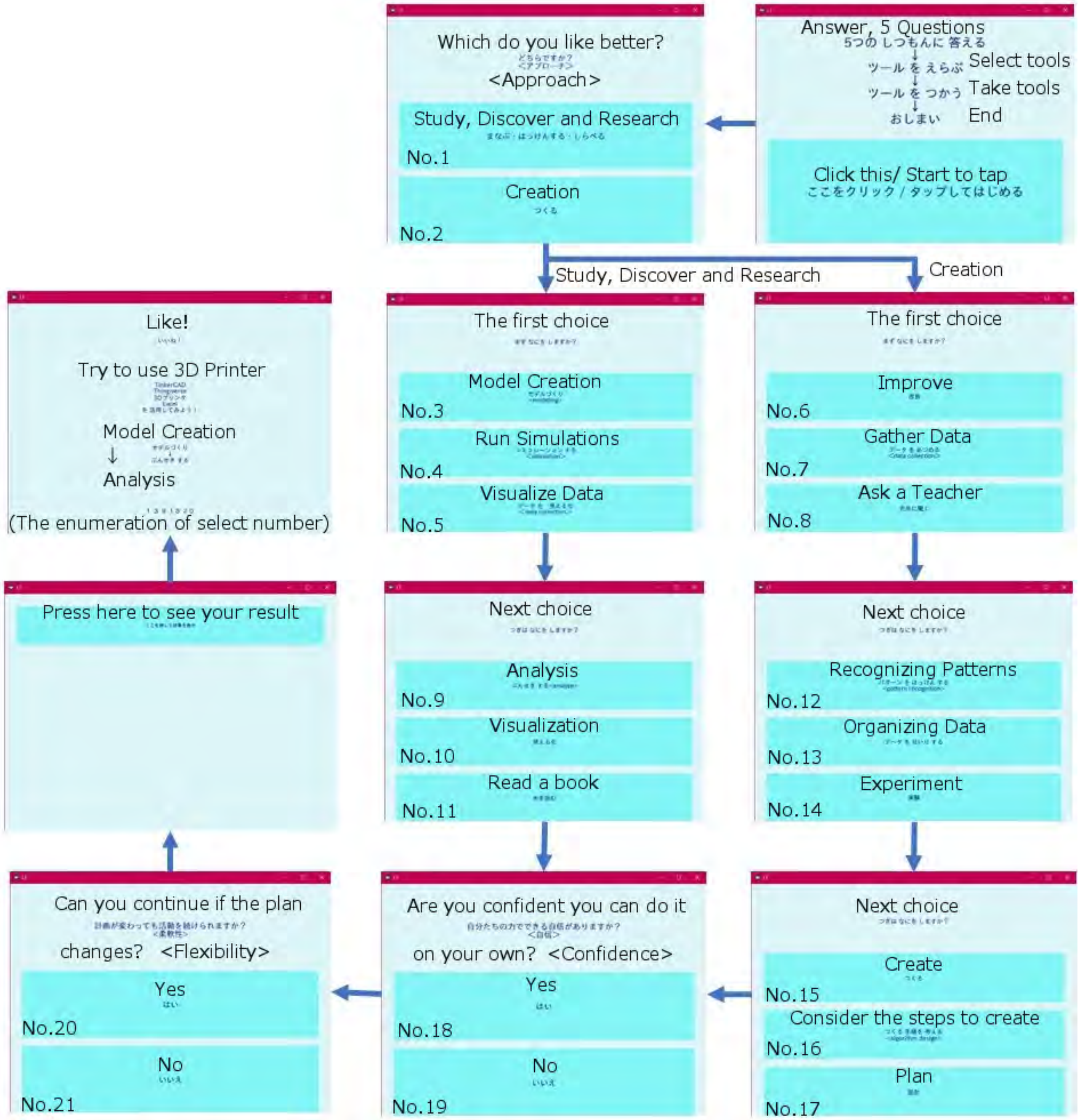

Figure 2 Tool screens

Results and Discussion

This tool received feedback from eight students at the Hokkaido Junior Doctor Course (hereafter HJDC). In one year or two years, HJDC is to find and educate the science innovation children, 11 to 15 years old, at Hokkaido in Japan. And then, HJDC does not have the relationship to junior high school education. The students in question were in their second year of studies and working on their independent research projects in HJDC. In addition, we contacted mentors supporting students and staff who were taking advanced courses at NIT, Asahikawa College (about the level of 3rd/4th year of university) (e.g., NIT, Asahikawa College, 2019).

The hearing was conducted as follows. Subjects used the application as intended and then answered a survey hosted on Google Forms. The questions shown on the survey are listed below, with the selectable answers following in 【】 brackets.

- Please provide your school grade. 【6th grade elementary school, 1st – 3rd grade junior high school and Mentor】

- Please enter the number displayed at the bottom of your results screen. If you watched a video, please select "video." 【Respondents can enter a number or select "video."】
- Do you think the answers provided to the questions match your research group? (Please skip if you watched a video) 【Didn't Match－1・2・3・4・5－Matched】
- Were any of the options given during the application close to what you were thinking? 【None－1・2・3・4・5－There were】
- Please select all options that reflect how using this application made you think about what direction to take your research project in. 【Nothing changed/I found what I should do/I felt there wasn't enough/Other (Free response) 】
- This is the final question. Please list any parts of the application that could be improved as well as any thoughts or feature requests. 【Free response】

Below are the results of their feedback. The path each respondent followed to reach their result as well as their number is displayed (Figure 3). There was no set pattern, with almost all respondents picking different options. Clearly, no one answer applied to all subjects.

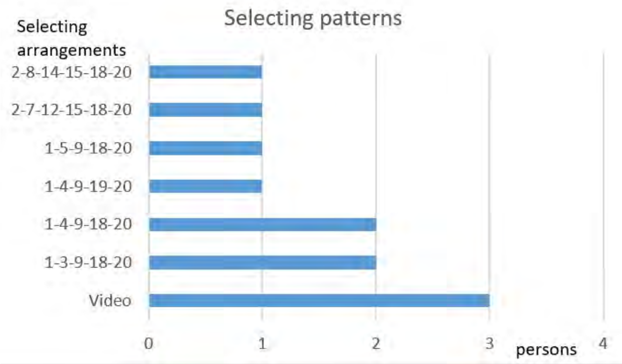

Figure 3 Set of options chosen by respondents

We also collected the feedback from the respondents (Table 2).

Table 2 Impressions after using tool

How You Think Direction Of Your Research Will Change	Respondents
Nothing changed	2 Mentors 3 Students
I found what I should do	3 Students
There weren't enough questions	1 Student
I don't know	1 Student

Students were split almost halfway between "Nothing changed" and "I found what I should do." Given the skill of the mentors, it is possible that they were split by expertise at programmer logic. Next is the free response answers from the subjects (Table 3).

Table 3 Thoughts, suggestions, and hopes for the tool

Grade	Free text
Mentor	>>Overall * If you change the text size when screen size changes, you might avoid text doubling up? >>Final page (Results) * Maybe pressing the "Press here for your results" button should hide them? The same text keeps popping up every time you press it. * Text started out doubled up at the default screen size.
Mentor	Questions were a bit vague, so kind a hard to tell what they asked.
Mentor	Text showed as doubled up or garbled, final button stuck me in a loop.
6th grade elementary school	It was hard. There were parts I didn't understand.
1st grade junior high school (JHS)	(It'd probably be hard to add since it'd add more patterns, but) I think there should be more options in the middle. But I thought it was innovative with how simple it was and how I obtained information that helped me figure out what to do. I think it's a wonderful application!
1st grade JHS	I liked how smooth it was to go through.
2nd grade JHS	The line on the last screen (Try using Excel) was a bit hard to read.
2nd grade JHS	I think it'd be good to make it just a bit simpler and go for ease of use. Sorry for taking so long with the survey.
3rd grade JHS	The results were doubled up and hard to read.
3rd grade JHS	I think it's really easy to understand for younger students. A lot of people don't know what to use to research or learn, so this is a great application. But my research is different from other people's (business plans) so I was a bit confused.

Next, we assess whether the teaching material our research created has met its goals.

(1) Require no experience with coding or programmer logic from teachers, (2) Be highly versatile, usable by teachers even outside of the field of information processing; The tool could be utilized outside the context of information processing simply by changing the placeholder text of the questions, so it could be said to have high versatility. We commented the code so that this can be done just by altering those parts alone.

(3) Deepen students' understanding of information literacy, CT and programmer logic.; We used this tool as an outline for CT and information literacy. By considering different combinations of research-crucial options, it is designed to train a student's programmer logic.

Conclusions

According to Table 2 and Table 3, we were able to obtain overall positive feedback from students, with feedback such as "It's simple" and "I found the information I needed for what I want to do." However, students tended to find it lacking due to this simplicity; perhaps due to the age of the subjects, or simply due to the audience of students enrolled in an early learning program. The tool might be better suited for those in lower grade levels.

In the future, we would like to conduct sampling of elementary and junior high school students to have more quantitative feedback. And then we would like to publish a tool that anyone can use.

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Pedagogy for Future Professionals

NGEE ANN POLYTECHNIC'S CHINA READINESS PROGRAMME: AN INTERDISCIPLINARY APPROACH TO FUTURE READINESS (ID: 23)

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Abstract
One of Ngee Ann Polytechnic's (NP) desired outcomes is to shape graduates who are ready for a global workplace. The Certificate in China Readiness (CCR) Programme is an example of a NP programme aimed at developing students into global-smart professionals. It is designed and developed to equip students with the knowledge and skills to understand China - be it for the purpose of pursuing a career or starting a business connected with China.
However, the challenge for the teaching team was to design a robust and engaging programme that would do justice to a fast-evolving and multi-faceted country like China and to create an immersive and transformational learning experience for the students. The outcome of the CCR design was anchored on providing students with authentic learning experiences that are interdisciplinary, so that students would have a holistic perspective of China, her culture, economy and people.
The immersive and holistic learning experience was created for students in two ways– first, through the inter-disciplinary approach where students learn and understand China's politics, business, culture and society using a variety of platforms such as debates, forums and art/culture appreciation to help students develop a more holistic knowledge and views about China. As a result, they develop greater cultural awareness, sensitivity and acquire multiple perspectives.
Secondly, Experiential Learning was adopted to provide students with authentic activities that are designed for students to gain concrete experience and engage in reflective observation, abstract conceptualization and active experimentation. This includes an Immersion Programme to China where students are able to interact with locals, conduct cultural analysis, perform business investigations and develop viable business proposals. Students were given insights into China business through visits and discussion forums with companies and industry partners such as Alibaba.
Feedback from students on the programme has been very positive especially for the conversations with industry partners which gave students insights into China's business and working culture. Students also acknowledged that their perspectives of China, Chinese culture and people have changed since the programme and are more ready to engage with China in future.
Keywords : *Experiential Learning, Active Learning, Inter-disciplinary studies, holistic, future-ready*

Introduction
The Certificate in China Readiness (CCR) Programme was developed by the School of Interdisplianary Studies and implemented in 2017 as part of Ngee Ann Polytechnic's (NP) intent to develop graduates for the global workplace. The rationale for NP to develop a China-focused programme was based on three key factors - the increasing importance of China in international politics and the global economy, China's close ties with Singapore as a trade partner and the increasing demand for graduates with knowledge of China.

In order for students to acquire a strong knowlege of China as a nation, business partner and society, the design of the programme needs to allow for sufficient opportunities for students to have deep engagement and transformative experiences with different aspects of China. Hence, the design of the progamme leverages on the use of the Constructive Theory and Experiential Learning as key approaches to provide students with active and authentic learning experiences and activities.

This paper intends to present the design and development of the CCR programme, the implementation and the outcomes of this programme for preparing graduates to be global professionals.

CCR : Design & Pedagogy
In order to achieve the aim of developing global ready professionals, the programme was designed with the following objectives:

- Develop an awareness of the values, beliefs and norms that shape the Chinese society
- Acquire insights into the business environment in China and how it operates
- Deploy strategies to interact successfully with the Chinese in both social and business contexts
- Spot business opportunities in Singapore/China arising from China's growth

The programme curriculum consists of three interacting modules stacked up progressively to provide students with a scaffolded learning experience that is cohesive and complete (see Figure 1).

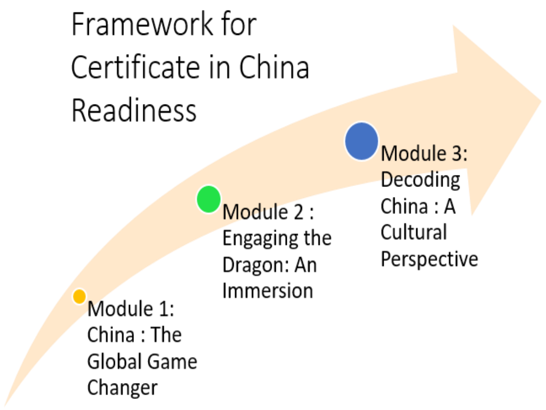

Fig 1: Framework for Certificate in China Readiness Programme

Module 1: *China: The Global Game Changer*
This module challenges students to re-examine stereotypical and outdated views of China and provide a lively platform for them to acquire an overview of China's amazing transformation, key growth areas and technological advancements. Students are also expected to analyze and critically discuss the impact of China's growth.

Module 2: *Engaging the Dragon: An Immersion*
In this module, students will have the opportunity to experience what they have learnt about China through an immersive study trip to China where students experience first-hand some of China's advancements in technology and also challenged to spot business opportunities. On the trip, students also interact with Chinese companies and local students from host institutions and glean the values that influence the business environment and social interactions.

Module 3: *Decoding China: A Cultural Perspective*
Students engage in more in-depth discussion and exploration of China's surface and deep culture in this module, appreciating concepts such "Guanxi" (relations) and "face" in this module. Through this module, students would examine the different factors and influences such as values, beliefs and norms that shape the Chinese society and develop an awareness of the cultural sensitivities. These intangible concepts do play a significant role when interacting and understanding Chinese.

Materials, Methods and Pedagogy

The constructivist approach was adopted in the instructional design of the programme. As put forward by Vygostsky's Social Constructivist Theory, providing the learning contexts are important in promoting student active learning (David, 2014). Knowledge is collectively constructed when students collaborate, negotiate viewpoints and exchange ideas. The teachers do not merely 'transmit' knowledge but collaborate with students and facilitate meaning construction. To promote such active learning, the programme is designed so that students have many opportunities to work in group and engage in peer learning. The following are some methods and activities that are used in each module to help students construct their own knowledge.

Collaborative Learning: Inquiring Questions
Short videos, articles and case studies are used in class for students to analyze the problems and strategize their solutions and recommendations. The design of these activities often requires students to work in groups within a short time frame (around 15-20 minutes) to deliberate on content issues and share their discussion via a 3-min presentation. The issues for deliberation are designed to be thought-provoking and require students to present credible arguments to support their answers. Some examples of the issues include "What are the reasons for China to block Facebook, Twitter, Google", "How Chinese companies acquire and develop technological capabilities", "Can you think of the pros/cons for having a Chinese Internet?".

Throughout the process of deliberation, students would engage with the content through debates and discussion to examine issues from different perspective before arriving at their conclusion. In addition, students will also acquire skills to learn collaboratively, develop critical thinking and gain stronger awareness of the different perspectives. During this module, students are not just building their technical knowledge on business environment in China, they are also developing industry-relevant skills that consider issues with deeper understanding from the perspective of the Chinese.

Collaborative Learning: Case studies
Short case studies were used in class for students to analyze the problems and strategize their solutions and recommendations.

Case study questions are also crafted as a scaffolding process to help students navigate and understand the complexity of issues. Wood, Bruner & Ross (1976) defined scaffolding as a process "that enables a child or novice to solve a task or achieve a goal that would be beyond his unassisted efforts." The cases need not be long but often involve complex and ambiguous situations. Students may understand the content and concepts but might not have master its application. Thus, using case studies could help them apply the knowledge effectively to the real-world or realistic scenarios.

Vygotsky's theory on the zone of proximal development is applied in the process of learning with a combination of scaffolded questions and tutor's facilitation. This is when students may be cognitive ready but require more knowledgeable and skillful guidance from tutors or/and collaboration with more capable peers to help them advance[1].

The constructivist approach is also well suited for the evolving nature of the subject matter; as it is aligned to the main objective of developing students' critical thinking, analytical skills, ability to connect the dots and make sense of the complex world. In the process, they learned to be attuned to the dynamism of the Chinese society, economy and culture. It is far more relevant if they can distill key concepts, analyze issues deeply through an inter-disciplinary approach rather than to memorize facts and content. Knowledge can be obsolete but their intellectual curiosity, analytical and critical thinking will enable them to be life-long learners.

Experiential Learning: Immersive Study Trip
David Kolb's Experiential Learning (EL) is also used to frame the CCR curriculum design. As the name suggests, experiential learning involves learning from experience. According to Kolb (1984), this type of learning can be defined as "the process whereby knowledge is created through the transformation of experience." It involves a cycle of four processes (see Figure 2). Apart from the China immersion trip, local learning journeys and key assessments are designed using the Kolb's principle – observe, think, do, feel. The experiential activities and assessments are presented in the following paragraphs.

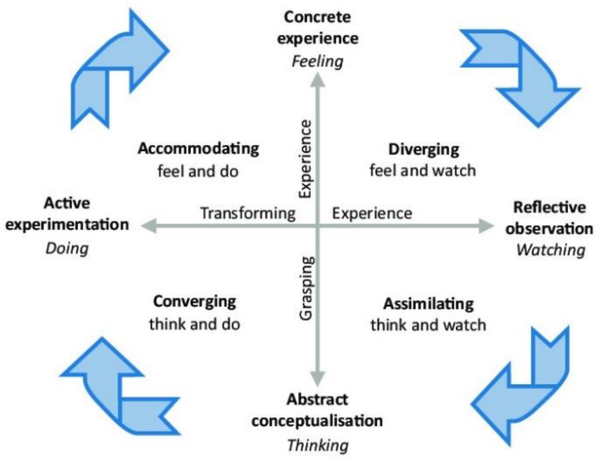

Fig 2 : Kolb's Experiential Learning Cycle

One of the key EL activities for students is the 2-week immersion programme where the CCR students spend time in China to experience for themselves, as one of their "concrete experience".

In the 2019, the trip was extended from 10 to 14 days to include twin cities, namely Shanghai and Hangzhou. This trip allowed students to "experience" China though a variety of interactive and immersive learning activities that were designed for them. These experiences include the attending seminars at Alibaba University (Hangzhou), visits to global companies such as Trip.com China Volkswagen in Shanghai, having social gathering with local Chinese students and forum discussion with Singaporeans living & working in China. These interactions expose students to how the Chinese work and study which in turn allows them to gain insights about the Chinese and their thinking.

Other than seminars, forum and company visits, the teaching team has also designed an interactive and immersive learning activity mimicking the TV Reality show "The Amazing Race". Students are required to work in a team, plan and strategize in navigating a Chinese city to accomplish a set of challenges such as finding a specific sub-way station exit, a local market, a unique cultural mural, make friends with the locals and try local snacks all on their own, allowing them to engage with the local community using their understanding of China and the Chinese people.

Picture 1 : Visit to Alibaba HQ in Hangzhou, September 2019

Picture 2: At Hema Supermarket to experience the new concept of operating supermarkets

1 "The distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem-solving under adult guidance or in collaboration with more capable peers." (Vygotsky, 1935)

Picture 3 : Entrepreneurship Forum with Singaporeans in China

As part of the EL cycle, students are required to submit a personal reflection piece on their experiences' as it is important to connect the learning context with the curriculum and to ensure the authenticity of the task (Beames, 2018). To emphasize on the value of the reflection process, their individually-written reflections are assessed; based on how well they made connections between first-hand experiences and secondary knowledge acquired from previous module and during the trip; their ability to synthesize and evaluate experiences and have deep authentic insights.

In the last 2 phases of EL (abstract conceptualization & active experimentation), students are expected to identify and observe one business both in Singapore and China so as to propose and develop a viable business plan, using the Strategyzer Business Model as part of their assessment. The business should be based on the Chinese city which they visited and how they could integrate some of Singapore's strengths and uniqueness which may contribute to business success.

Picture 4 : Examples of students proposal using China's Dairy Company Mengniu to propose a specialty yoghurt shop

Developing Culture Quotient

Module 3 delves deeper into the values and norms that shape the behaviour and values of the Chinese. Students could utilize by now, more in-depth knowledge of the Chinese culture to further explore, connect, and analyze deeper issues and abstract cultural nuances.

In designing this module, the teaching team referenced the iceberg analogy of culture by Edward T. Hall and Hofstede's Cultural Dimensions. Hall explained that if the culture of a society was the iceberg, then there are some aspects visible, above the water, but there is a larger portion hidden beneath the surface (Hall, 1976). What is visible is only the 'tip of an iceberg' – the most overt and apparent. In order to understand and engage China effectively, students need to uncover the values and beliefs that underlie the behavior of that society and move away from stereotypes and identify the 'invisible' deep culture of beliefs and values.

To further identify some of the deep culture and beliefs in China, Hofstede's Cultural Dimensions is adopted (Hofstede's Cultural Dimensions Theory, 2017). Instead of focusing on all six dimensions, the teaching team selected the relevant ones such as collectivism, and power-distance (social hierarchy/face) to explain how the Chinese think, behave and organize themselves at both the micro and macro levels (figure 4).

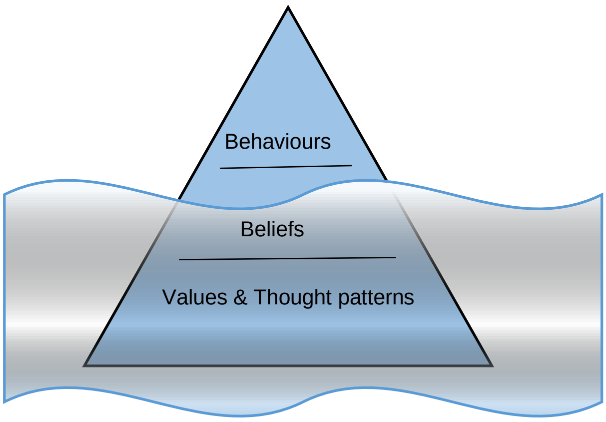

Figure 3 : Hall's Cultural Iceberg

Figure 4 : Hofstede Cultural Dimensions Theory

One of the learning activities which is a Learning Journey to the National Gallery of Singapore was specifically designed to help students "uncover" the hidden aspects of Chinese Culture and understand the values of Chinese.

Through the use a visible/concrete culture – Chinese Ink Paintings, it bridges the understanding of Chinese deep culture, philosophy and values. Tutors facilitate the observation, discussions and deep critical thinking using selected art works displayed at the Gallery. Through observation, discussion and tutor's facilitation, students are able to connect the visible/visual aesthetics to understanding the invisible values such as high context communication, conforming to hierarchies.

Learning came alive when students are able to make deep connections between the symbolism in the art works referenced by Chinese cultural practice. More importantly, students are able to successfully identify, apply and interpret the Chinese values and virtues taught in prior lessons; which include benevolence and reciprocity.

The Gallery learning has been positive as shown in the evidence of the student personal reflections:

"*We were brought to sit in front of paintings, where we were to create discussions about them. Before that, paintings were pieces of paper to me. They were nice to look…but never more. As the discussion continued,* ***my perspective on Chinese ink and ideas about the Chinese culture began to broaden****, as we delved deeper into the meanings*." *(Student, 2017)*

"I was skeptical at first, how much meaning can a pair of peacocks and deers actually hold? But after listening to the explanation, I was amazed and impressed. I learnt that the spread of peacock's tail was likened to the shape of an official's headdress, a play on words 'guan' meaning officialdom in Mandarin. While 'lu' deer is a homonym for wages or income. I also learnt that people, objects, or animals are often drawn in pairs in Chinese painting as they represent reproduction, good luck…good fortune and prosperity." (Student 2017)

"*This learning journey has helped me to appreciate the Chinese culture by allowing me to see the teachings of Confucianism even in modern day… (Wu Guanzhong) he exhibited the Confucius traits of benevolence and loyalty. He exhibited benevolence through freely giving his paintings to Singapore even though he had fame and could easily sell them. He also exhibited loyalty by remembering that Singapore helped him gain fame. He showed his loyalty by giving his paintings to Singapore before he died...." (Student, 2018)*

Results and Discussion

One of the key indicators adopted by NP to review the teaching and learning experience is the Module Experience Survey (MES) where students are asked to review the modules at the end of the semester in areas such as Skills & Knowledge, Teaching & Learning, Feedback, Thinking, Materials and Activities. Since the CCR has been implemented in 2017, and the data collated for the three modules shows higher MES score than the NP average, which is around 4.8 (out of maximum 6).

Module/Academic Year	2017	2018	2019
Global Game Changer	5	5.2	5.1
China Immersion	5.6	5.6	5.5
Decoding China	5.4	5.4	5.3

Table 1 : Overall Module Experience Survey

In addition, the qualitative data collected from students' feedback evidence its positive impact. Comments by the students have indicated that the objective of the programme to prepare students for work and study in China and to provide them with deeper insights into the Chinese society have been achieved.

(The selected comments are given anonymously by students in in the Module Experience Surveys.)

"I like most about the learning environment, as all the student are here for more insights of China, our tutor given us many deep thoughts and expose us to topics that I did not aware of before I attend her lesson, like "Left over children and China policies."

"I love the knowledge I gain from this module, it helps me to better understand and decode China. If I were to visit or work in China in the future, I would definitely be able to make good use of what I learnt in this module....."

"I highly enjoy attending IS classes especially for China lessons. Everything I learnt is useful and could be of good use in the future if I were to venture into China.".

Another positive outcome of this programme can be seen through students who have taken a stronger interest in working in China as this programme also prepares students for their internship experience in China. Students have credited the programme for preparing them for the complexities of working and living in China.

"*The knowledge learnt in CCR was extremely beneficial when I interned in Shanghai. As a sales frontline, I dealt with Chinese customers and businesses daily. Knowing how to deal with the Chinese allowed me to successfully clinch collaborations with businesses, draft targeted messages to capture the attention of Chinese customers*" *- CCR student, who went for 6-month internship in Shanghai*

Conclusion

The intention of the CCR programme was to prepare NP students to be global ready professionals and to have a stronger awareness and understanding of China, the

Chinese business environment and society so that students are more prepared to work and study there.

Data collated and feedback from students have been positive as the programme has changed their mindset about China and Chinese society. While the long-term impact of this programme on preparing students for work and study in China is still not evident as yet, there are positive indicators based on the high MES scores, the postive comments by students and also the increased openess of students to learn more about China and the willingness to work there.

The inital success of the CCR has also resulted in a similar programme for adult learners such as Travel & Learn Programme for the PMET, which has also recieved positive feedback and comment[2]. Going forward, the teaching team may have to work in an increasingly dynamic environment in both China and the world as they naviagate how to continue to allow students to experience similar level of engagement with China and the Chinese society in the post-COVID world.

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[2] PMET in Singapore refers to Professionals, Managers, Executives and Technicians

POSSIBILITY OF DEVELOPING LEGAL MIND IN CAREER AND GLOBAL EDUCATION

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Abstract

Amid the ongoing globalization, English or global education among KOSEN has been changing. We think it is necessary to give students more opportunities before they graduate from KOSEN to consider their future careers and experience in handling difficult legal issues at work. In 2019, we surveyed teachers and students in a Hong Kong institute and a Singapore institute to understand the actual situation of careers and global education in Asian countries. We enquired into the conditions that students should be aware of with respect to their career, what qualities and abilities they need in order to adapt to globalization, and so on. The results revealed that teachers regard "business ethics," related to laws or social rules, as an important factor in career education. Developing a "legal mind," which can be defined as an ability to find a reasonable solution for social or business problems in the context of laws, could be an important factor for global education. Further, we surveyed the students of our college, Tomakomai KOSEN, on the same questions to compare the results between Japan and Asian countries. We also conducted a survey of Japanese workers in Hong Kong regarding their opinions about careers and working overseas. We found that the students of the surveyed institute do not consider "business ethics" to be important, while some Japanese workers in Hong Kong regard business ethics as being important. We think it is necessary to create awareness among students about the importance of business ethics or laws. On the assumption that having opportunities to learn legal issues would help students develop their careers as global engineers, we plan to organize a new workshop for developing "legal minds" that would be conducted in the international exchange program of Tomakomai KOSEN. The workshop will give students a simulated experience to consider social or business problems and find a reasonable solution in discussion with others.

Keywords: *career education, global education, laws, legal mind, Asian countries*

Introduction

The purpose of education at National Institute of Technology (hereafter, "KOSEN") is to foster and train practical technicians. As globalization progresses rapidly, KOSEN are being charged with the education of technicians who can be active globally. Aesmen (2008) mentions legal issues as a key element of project management in the globally progressing engineering field, and Atsumi (2013) proposes the strengthening of "legal minds" in the education of global human resources.

A "legal mind" refers not only to the acquisition of knowledge about and an understanding of laws, but also the "legal ways of thinking" needed in negotiations and problem-solving based on laws and regulations. More broadly, the legal mind also encompasses common practices and culture. In fact, the ability to coordinate and make adjustments between interested parties to lead to reasonable solutions is essential for adapting within a global society.

In 2019, at the 13th International Symposium on Advances in Technology Education (ISATE 2019), we reported the results of our questionnaire survey of the teaching staff (hereafter, "staff") at educational institutes in Hong Kong (hereafter, "HK") and Singapore (hereafter, "SG"). The survey was performed as a step towards program development for fostering a legal mind. The survey questions concerned career education and global education performed by the aforementioned institutes. As for students' considerations about their future careers, not only "life plans," "work promotions," and "salary", but also "company ethics" ranked high. Inasmuch as company ethics are related to the social responsibilities of companies, including conformance to laws and regulations, our survey indicated that an emphasis is also placed on socio-legal aspects.

With regard to global education, a few participants responded with "differences in laws and social rules" as a cause of problems that could occur if students were to decide to work abroad in the future. This reveals that one aspect of global education could be the understanding of other societies through an understanding of their laws.

Having obtained these results, to continue our investigation, similar surveys were conducted with students of both the aforementioned regions (HK and SG), Japanese (JPN) students, and JPN workers in HK. We then compared these results with those for the staff, and compared the results among the students. This paper reports the results, and their analysis. We also offer a broad overview of the program for fostering legal minds, which we intend to implement in the future.

Performance of the questionnaire survey

We conducted a questionnaire survey of students at both of the above institutes, and of the JPN students at Tomakomai KOSEN. The survey questions were about career education and global education. To include the opinions of the people who were actually working abroad, we also performed a survey of JPN workers working in HK, using the same questionnaire. Question items described in this paper are presented in Table 1.

Table 1 Questions

	Target	Questions
Career Education	Staff, Students, Workers	Q1. Which items do you think students should be aware of when they think of their future career?
Global Education	Staff, Workers	Q2. To what level is it necessary for students to acquire each of the following?
	Students	Q3. To what level have you acquired each of the following?
	Staff, Students, Workers	Q4. When a student goes to work in a foreign country, what are the causes of trouble or difficulties he or she might face?

Question 1 (Q1) permitted multiple answers from nine options. For Question 2 (Q2) and Question 3 (Q3), there were 13 items, each of which was selected using a scale from 1 (Not at all) to 5 (Very much so). For Question 4 (Q4), from seven options available, the respondents had to choose two. Table 2 presents the number of respondents, which also includes respondents from the previous questionnaire survey described above.

Table 2 Number of respondents

	Workers	Staff	Students
Japan	25		121
Hong Kong		26	67
Singapore		8	20

Results and Discussion

(1) Career Education

First, we look at the results for Q1, "Which items do you think students should be aware of when they think of their future career?" Figure 1 and Figure 2 present the graphs indicating the percentage of responses for the nine choices. Here, a classification can be made into three groups: company ethics, promotion, site of workplace, salary can be grouped under "Company appeal" while, life plan, qualifications can be placed under "Personal conditions," and finally gender equality, company benefits, labor laws under "Company system." The surveyed staff emphasized "Company appeal." Remarkably, we can observe that the SG staff focused on "site of workplace." This reflects that this small urban nation, SG, located at the southernmost part of the Malay Peninsula, is the gateway to ASEAN countries and serves as the hub for foreign corporations who seek to expand their business throughout the ASEAN region (Calder, 2016). Thus, "site of workplace" likely confirms this broad-ranging perspective. Meanwhile, student responses clustered at three points, life plan, salary, and company benefits.

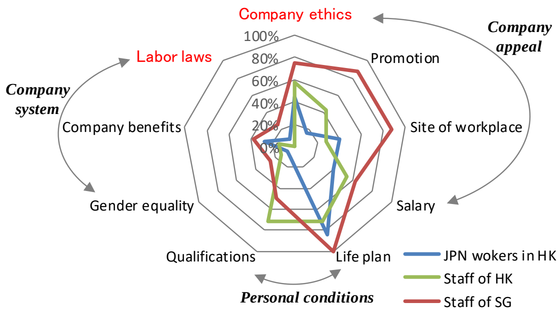

Figure 1 Responses of staff and Japanese workers

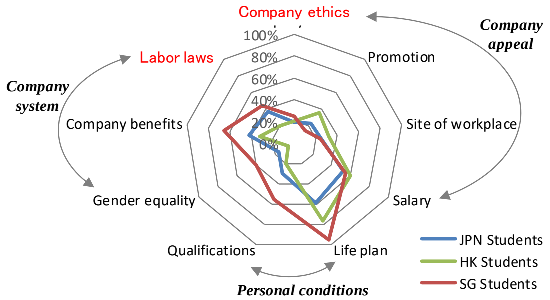

Figure 2 Responses of students

Next, we look at "company ethics" and "labor laws," the options that related to "legal mind" which is the focus of the present study. Although the staff and JPN workers emphasized "company ethics," the relative student awareness was considerably low. When considering their future career, the staff wanted students to emphasize aspects connected with the general society, including conformance to laws and regulations, and societal contributions. Meanwhile, students are orientated towards personal benefits, such as the above-mentioned life plan, company benefits, and salary.

As for “labor laws,” students had a higher percentage compared with the staff and JPN workers in HK. Perhaps this is due to an awareness that students have gained through their part-time work experiences, that labor laws are an essential means of protecting their rights in industrial relations.

While the staff emphasizes company ethics, students prioritize labor laws. In terms of a legal mind, however, both ethics and laws are involved. In this regard, while the staff and students may have different viewpoints, both groups actually desire similar elements in their career education. Therefore, the questionnaire results of this study can be said to support the potential of introducing the development of legal minds within career education.

(2) Global education

Table 3 outlines the 13 items specified as necessary qualities for adapting to globalization, most of which are based on the definitions of “global human resources” outlined in 2010 by the Ministry of Education, Culture, Sports, Science, and Technology (MEXT)-related institution in Japan. For these items, the Questionnaire for the HK and SG staff and for the JPN workers in HK asked Q2 “To what level is it necessary for students to acquire each of the following?” (hereafter, “acquisition necessity”), and each student was asked Q3 “To what level have you acquired each of the following?” (hereafter, “acquisition level”).

(2) -1 Acquisition necessity

Questionnaire results were evaluated in the following two steps.

Step 1: The priority level of each item, and the qualities by country were ascertained by using basic statistical amounts.

Step 2: Principal component analysis was performed to ascertain the type of human resources necessary for globalization.

(2) -1-1 Basic statistical values

Table 3 Necessary qualities for globalization

1) English proficiency
2) Communication skills
3) Understanding of other cultures
4) Understanding of own country’s culture
5) Understanding of other countries’ laws or social rules
6) Understanding of own country’s laws or social rules
7) General knowledge
8) Positiveness
9) Challenger’s spirit
10) Cooperativeness
11) Sense of responsibility
12) Identity as JPN/HK/SG people
13) Technological skills

Table 4 presents the averages and standard deviations for the Questionnaire results. Items in Table 4 that have high average values and low standard deviation signify that many respondents felt that the item was highly necessary. Asterisks (*) in the Table indicate items rated with high levels of importance. The “level of importance” was calculated using the averages and SDs as follows.

*** : The average is greater than 4.5, and the SD is less-than 0.5
** : The average is greater than 4.5, and the SD is less-than 0.7
* : The average is greater than 4.0, and the SD is less-than 0.8

Hence, we can observe that JPN workers, and the staff of HK and SG all placed emphasis on item two—Communication skills, which also had the highest overall value. Worthy of note is that items five and six—Understanding of laws or social rules—were rated high by SG staff. SG is a multicultural society comprising diverse races, including Chinese, Malays, and Indians. It is thought that these questionnaire results prove that they must adjust to different cultures and societies with an understanding of laws and social rules—in other words, a legal mind is essential. A further trend observed that JPN workers find item eight and nine extremely important i.e. “Positiveness” and “Challenger’s spirit” respectively.

Table 4 Averages and Standard deviations

	JPN workers in HK		Staff of HK institute		Staff of SG institute	
	Average	Standard deviation	Average	Standard deviation	Average	Standard deviation
1) English proficiency	4.20	1.00	**4.73	0.53	***4.75	0.46
2) Communication skills	***4.72	0.46	***4.73	0.45	***4.88	0.35
3) Understanding of other cultures	**4.52	0.65	3.65	0.75	***4.75	0.46
4) Understanding of own country’s culture	**4.44	0.65	3.81	0.90	*4.38	0.52
5) Understanding of other countries’ laws or social rules	3.80	0.87	3.88	0.71	*4.25	0.46
6) Understanding of own country’s laws or social rules	3.80	0.65	3.96	0.77	*4.13	0.35
7) General knowledge	*4.20	0.76	3.96	0.60	*4.13	0.64
8) Positiveness	***4.88	0.33	*4.23	0.65	4.00	0.93
9) Challenger’s spirit	***4.84	0.37	4.04	0.82	4.00	1.07
10) Cooperativeness	**4.72	0.61	*4.46	0.58	*4.38	0.52
11) Sense of responsibility	*4.48	0.77	***4.73	0.45	**4.50	0.53
12) Identity as JPN/HK/SG people	4.08	1.00	3.35	1.06	3.63	0.92
13) Technological skills	3.36	1.04	4.29	1.08	3.88	0.64

(2) -1-2 Principal component analysis

Table 5 displays eigenvalues and contribution ratios. Table 6 presents the principal component loads; here, the higher the absolute value, the stronger the contribution of the variable. It can be seen from Table 6 that the first principal component expressed "Sociability," inasmuch as Identity, Positiveness, Challenger's Spirit, and Understanding of other cultures had high absolute load values. The second principal component was "Skills," as English proficiency and Technological skills can be interpreted as the application of technical skills while using the English language. The third principal component are all items related to Understanding, and this is expressed comprehensively by "Understanding of different cultures", including an understanding of one's own country. The fourth principal component could not be analyzed. Principal components with an eigenvalue under 1 are determined to be insignificant; therefore, we will lay focus up to the third principal component, with eigenvalues of 1 and above.

In Figure 3, the horizontal axis depicts the first principal component, and the vertical axis, the second principal component. From the figure, it can be noted that JPN workers were distributed widely from the top to the bottom, and are located towards the right, which indicates that these workers desired overall "Sociability." The HK staff is located at the top left, indicating a trend where "Skills" rather than "Sociability" is demanded. The SG staff, due to their small sample numbers, is not represented clearly.

Next, Figure 4 plots the second principal component on the horizontal axis, and the third principal component on the vertical axis. In the figure, a majority of the HK staff are on the right but lower than the x-axis vicinity. This indicates that "Skills" is emphasized more than "Understanding of different cultures." Meanwhile, the SG staff is mostly on the positive side of the y-axis, with a demand for human resources with "Understanding of different cultures" rather than "Skills." The above result establishes that JPN workers in HK value "Sociability," HK staff favor "Skills," and the SG staff attach importance to "Understanding of different cultures."

(2) -2 Acquisition levels

Here, we discuss the responses of JPN, HK, and SG students to Q3, "To what level do you think you have acquired each of the following?"

(2) -2-1 Basic statistical values

Figure 5 presents the mean and median values of the questionnaire results. A "median value" means that half of the respondents chose the median value or above. Additionally, where the mean values are equivalent but median values differ, this indicates that the group with the higher median value had a higher acquisition level.

From Figure 5, we see that for items 10—Cooperativeness and 11—Sense of responsibility—items of emphasis by the teaching staff, student acquisition levels were high in HK and SG. Thus, the fostering of

Table 5 Cumulative contribution ratios (Q2)

Principal number	Eigenvalues	Percentage of variance (%)	Cumulative contribution ratio (%)
1	2.0	27.1	27.1
2	1.3	17.3	44.4
3	1.1	14.4	58.7
4	0.7	9.4	68.1

Table 6 Principal component loads (Q2)

	PC1	PC2	PC3	PC4
1) English proficiency	-0.1445	0.4612	0.2038	-0.3736
2) Communication skills	0.0118	0.1193	0.2268	-0.1393
3) Understanding of other cultures	0.4640	-0.2668	0.3882	-0.0953
4) Understanding of own country's culture	0.4671	-0.0745	0.4047	-0.3390
5)Understanding of other countries' laws or social rules	0.0597	0.1120	0.5650	0.3770
6) Understanding of own country's laws or social rules	0.2012	0.1003	0.4464	0.1498
7) General knowledge	0.2240	0.1365	0.0007	-0.0181
8) Positiveness	0.4711	-0.0126	-0.1698	0.2249
9) Challenger's spirit	0.6738	0.0221	-0.1355	0.2302
10) Cooperativeness	0.2771	0.0405	-0.0457	0.2616
11) Sense of responsibility	0.1120	0.2767	-0.0907	-0.0083
12) Identity	0.8312	0.3501	-0.3154	-0.2345
13) Technological skills	-0.2021	0.8695	0.0491	0.1783
	Sociability	Skills	Understanding of different cultures	

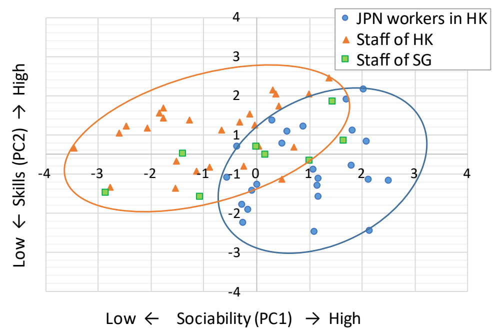

Figure 3 Score scatter plot of component 1 vs 2

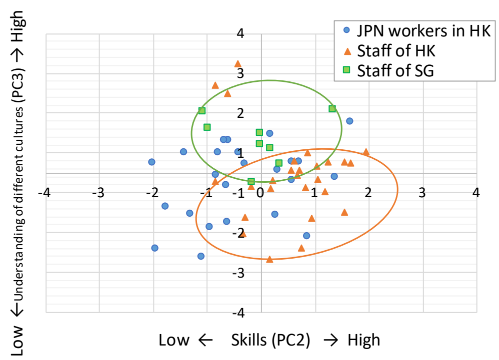

Figure 4 Score scatter plot of component 2 vs 3

"Cooperativeness" and "Sense of responsibility" is thought to be emphasized in HK and SG.

Meanwhile, for items three and five related to the legal mind, JPN students had a tendency to be lower than the others.

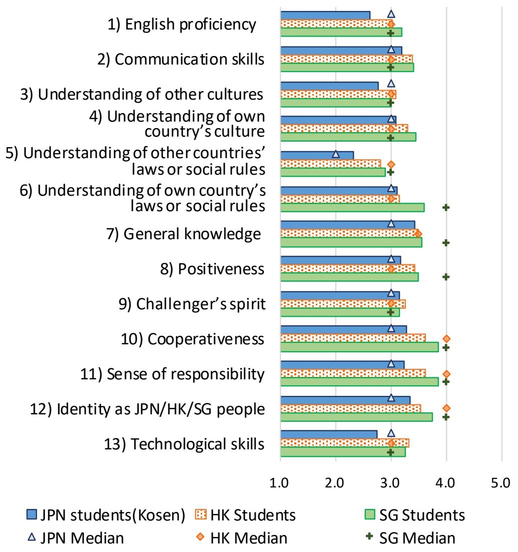

Figure 5 Mean and Median of Q3

(2) -2-2 Principal component analysis

Table 7 shows eigenvalues and contribution ratios, while Table 8 shows principal component loads. In Table 8, the first principal component expressed "Comprehensive abilities," inasmuch as all categories were on the plus side, with high values. As for the second principal component, items 3–5 were negative, while items 8–9 were positive; thus, this was called "Motivation." Similarly, the third principal component was "Identity," and the fourth principal component was "Skills." Figure 6 is a plot of the first and second principal components, which had eigenvalues over 1 (in Table 7). Since the number of survey respondents differed considerably by country, we cannot confirm the following with certainty; however, we do note that HK and SG students had high "Comprehensive abilities," and JPN students had low "Comprehensive abilities," with "Motivation" somewhat high. As for items 8 and 9 indicating "Motivation" in Table 8 (the second principal component), the Table 4 responses for JPN workers showed this had an extremely high level of importance; this indicates that, in JPN, a high emphasis is placed on "Motivation."

(2) -3 Causes of trouble or difficulties

Table 9 presents the results of Q4 "When a student goes to work in a foreign country, what are the causes of trouble or difficulties he or she might face?" With regard to understanding the "Differences between laws or social rules," response percentages were around 30%. This proves that, in global education, enabling a deeper understanding of laws and social rules should be a point of consideration, at least to a certain extent.

Table 7 Cumulative contribution ratios (Q3)

Principle number	Eigenvalues	Percentage of variance (%)	Cumulative contribution ratio (%)
1	5.7	50.9	50.9
2	1.2	10.6	61.5
3	0.9	7.6	69.1
4	0.6	5.5	74.6

Table 8 Principal component loads (Q3)

	PC1	PC2	PC3	PC4
1) English proficiency	0.6688	-0.0378	-0.2572	-0.3477
2) Communication skills	0.6427	0.1390	-0.2614	0.1161
3) Understanding of other cultures	0.7553	-0.4375	-0.1566	0.1853
4) Understanding of own country's culture	0.6458	-0.3427	0.1997	0.1887
5)Understanding of other countries' laws or social rules	0.7148	-0.5943	-0.1617	-0.1033
6) Understanding of own country's laws or social rules	0.6536	-0.1844	0.3269	0.0643
7) General knowledge	0.5183	0.0558	0.2065	0.1724
8) Positiveness	0.6636	0.3518	-0.2081	0.0330
9) Challenger's spirit	0.6915	0.4002	-0.2398	-0.0066
10) Cooperativeness	0.6531	0.2399	-0.0030	0.3201
11) Sense of responsibility	0.7132	0.2919	0.0841	0.0759
12) Identity	0.5997	0.2046	0.6081	-0.2261
13) Technological skills	0.6710	0.0095	0.0081	-0.4567
	Comprehensive abilities	Motivation	Identity	Skills

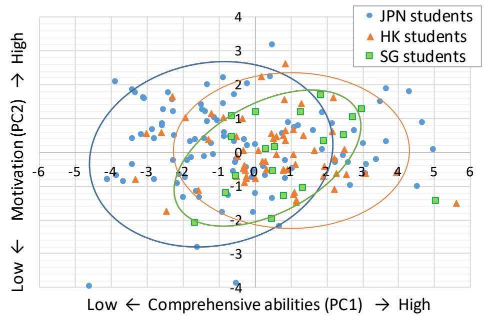

Figure 6 Score scatter plot of component 1 vs 2

Table 9 Causes of trouble or difficulties

	JPN(%)		HK(%)		SG(%)	
	Workers	Students	Staff	Students	Staff	Students
English proficiency	12.0	37.2	78.6	58.8	12.5	45.0
Communication skills	76.0	52.9	35.7	48.5	50.0	90.0
Difference between cultures	56.0	52.1	42.9	36.8	87.5	40.0
Difference between laws or social rules	32.0	30.6	28.6	29.4	25.0	30.0
Lack of general knowledge	20.0	18.2	7.1	16.2	12.5	20.0
Lack of Technological skills	4.0	3.3	7.1	11.8	12.5	5.0
Others	16.0	1.7	0.0	0.0	12.5	0.0

Program scheduled for implementation

Based on the questionnaire analysis described above and the results presented in Table 9 (the section just above), we will create a program for the education of a legal mind. This program will consider problems likely to occur when students work abroad in the future, as well as the human relationships they will encounter. Contents will be designed to give students experiences that will lead to reasonable solutions of problems through logical thinking and via adjustments and coordination among interested parties, all based on a “legal mind.” This plan will be implemented within a student exchange and training program between the Tomakomai KOSEN and the HK institute. Specific implementation methods are listed below.

1. Themes will be set for common social problems involving laws and rights, with introduction of conditions and the opposing positions of interested parties.
2. A mixed group including students from both countries will discuss individual ideas about problem-solving methods, with explanations provided for the relevance of these methods.
3. Each group will select what they consider to be the best solution method, and make presentations thereof to other groups.
4. Recapitulation and reflection regarding the processes of the group interactions and conclusions will be executed.

HK experienced rapid economic development under British capitalism. However, since becoming a Special Regional Administrative Region before its return to China, prior research has indicated that there has been little involvement in Hong Kong by labor unions in wages and working conditions, with no adoption of models like that of Anglo-American collective bargaining, or those involving political movements including labor movements (England, 1981). Thus, it may be that JPN and HK students will have different levels of interest regarding issues of law and rights; one can also imagine that opposition of opinions and other problems will occur. In fact, this program aims to give students experiences where they will have to confront such conflicts and problems stemming from “different cultures,” as they work towards coordinating and resolving these conflicts.

Conclusions

The summary of the analysis results from the questionnaire surveys conducted on career education and global education is listed below.

1. In career education, the teaching staff emphasized “company ethics,” while students had a higher awareness of “labor laws” compared to the teachers.

2. In global education, both the teaching staff and JPN workers in HK emphasized “sociability,” “understanding of different cultures and others,” and “skills”—in other words, “the application of their technical skills using the English language.” The JPN workers in HK especially emphasized “sociability,” while the HK teaching staff emphasized “skills," and “understanding of different cultures and others” was emphasized in SG.

3. With regard to “acquisition level” of global adaptability among students, HK and SG displayed a high tendency towards “comprehensive abilities,” which included a variety of elements, while Japanese students had a tendency towards high acquisition of “motivation.”

In global education, sociability, an understanding of different cultures and others, and the acquisition of English and technical skills are considered important. Added to this should be opportunities to learn and acquire a “legal mind,” with the ability to find reasonable solutions to problems based on an understanding of “laws and social rules.” With this addition, students will gain abilities that will enable them to adapt to new aspects of global societies.

Acknowledgements

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SUPPORT GROUPS FOR MAKING THE MOST OF SELF-ACCESS LEARNING

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Abstract

ICT has advanced so much that students can now study online anytime, anywhere. However, having the freedom to do it anytime, anywhere can easily lead to the postponement of learning if students cannot control themselves.

Individual Online English Conversation Training (OECT) was introduced to NIT, Akashi College in October 2017, and 59 people applied for it. In April 2018, about a quarter of the students at the college (225 students) applied for it. The attendance rate was expected to be high because it was based on voluntary participation. Each person had to pay 25,000 yen per year to attend. And, by showing the students that the average attendance rate at the end of the previous academic year was only 13%, the students could understand that keeping up with OECT could present a considerable challenge.

The teachers encouraged the students with an e-mail newsletter every Friday and tried to make a learning community in each class. However, the average attendance rate in April 2018 was only 38%. It dropped to 8% in March 2019 after one year. And, the attendance rate of the students who had taken more than 50% of the lessons was only 5%. Furthermore, the percentage of students who had not taken a lesson even once in the month of March 2019 was 74%.

From April 2019, we switched our support strategy from motivating individual students to developing good study habits within small groups. A small group of four students was made, which included one student who had already acquired good study habits and three students who could not continue the self-access learning without support. The group determined a meeting time and place and the amount of learning that they wanted to set as a goal. The students who thought they could not continue without the support group kept a high attendance rate. This paper describes how to support the development of good study habits in such groups and how to increase attendance rates for self-access learning activities. And now, many students are beginning to start their own small groups.

Keywords: *SAL endurance, online self-access learning, learning support group, attendance rate*

Introduction

Some fear that schools might no longer exist if online learning, such as MOOCs, becomes more prevalent and enables students to continuously learn knowledge and skills by themselves. However, as far as the results of this study and existing research from Funamori (2013) are concerned, in-person schooling would not disappear in response to advances in online learning even with respect to classes designed for acquiring the same knowledge and skills. This is because very few students find it easy to endure self-access learning (SAL) on their own. At the same time, as pedagogy evolves with advances in technology for education, teachers will need new skills and knowledge to support learning with online content and to help students acquire the study skills they need to endure SAL.

One long-term benefit of online learning is that it offers the convenience of gaining knowledge and skills after graduating from school. Therefore, developing SAL endurance for and through online learning has become increasingly important for life-long learning. There are studies on adult self-directed learning in Merriam (2001) and on student competencies needed for online learning in Latchem (2014), but these only focus on learning on an individual basis.

In contrast, this study focuses on how and why to create support groups for SAL. The study shows that there is no relationship between the competencies tested on the PROG test and the attendance rate of the OECT, and it shows how the motivation of unsupported SAL students is likely to disappear over a short period of time. However, through a support group, which offers slight adjustments to SAL conditions, participation rates are seen to rise regardless of how high or low previously perceived levels of motivation and competencies were.

Methods

The type of OECT currently used by Akashi College students provides 26 different lesson tracks and supporting materials, including vocabulary and grammar practice, standardized English test preparation, business English instruction, and a variety of courses for English conversation. Enrolled students can receive a 25-minute lesson every day with a choice of instructors from more than 76 participating countries; and, for an extra fee, they can connect with instructors who are native English speakers.

An OECT briefing session was held at the end of the academic year for returning Akashi College students in February 2018 and again at the beginning of the next academic year for new students in April 2018. From then on, a total of 225 students had signed up for a full year of OCET for an annual fee of ¥25,000 (roughly US$230). At the same time, five professors at Akashi College also volunteered to take OCET courses from the same company, and they offered support to Akashi College students, who were engaged in OCET, in three ways by:

1) e-mailing a newsletter to students every Friday
2) trying to make a learning community in each homeroom class
3) presenting awards for the top 10 students with the highest attendance rates in summer vacation.

Some of the supporting teachers were also in charge of administering the PROG test in January 2019 to gauge the students' competency levels. The PROG test has been administered at Akashi College annually since 2016 to track improvements in student competency levels from their 2^{nd} to 4^{th} year in the technical college. Table 1 shows the competency structure of the PROG test.

From April 2019, we switched our support strategy from motivating individual students as parts of a larger whole of e-mail recipients and homeroom classes to developing good study habits within smaller support groups. One such group of four students was made, which included one student who had already acquired good study habits and three students who could not continue the self-access learning without support. The group made ongoing promises to each other regarding when, where, and with whom they would practice OECT, and this created an awkward state for anyone you might have failed to participate. The daily OECT time was set from 8:30am to 8:55am, Monday to Friday, before ordinary classes started for everyone.

Results and Discussion

Looking back at the 2018 academic year, the monthly attendance rate distribution from April 2018 to March 2019 is shown in Figure 1. The attendance rates are somewhat evenly distributed across the board from those with low attendance rates to those with high attendance rates at the beginning of the OECT lessons in April 2018. However, the low attendance rates increase significantly with the passing each of month. The percentage of students who did not attend at all for one month was 18% in April 2018, but that reached 74% in March 2019. The percentage of students who attended 50% or more was 40.5% in April 2018, and that decreased to 4.9%. This showed that encouraging the students with e-mail and

Table 1Competency Structure of PROG

	Main Categories	Subcategories	Specific Characteristics
Competency	Collaboration	Affinity	Friendliness
			Consideration of others
			Interpersonal interest, sympathy, acceptance
			Understanding, awareness, and tolerance of diversity
			Fostering of personal relationships
			Trust building
		Cooperation	Understanding of roles and collaborative behavior
			Information sharing
			Mutual support
			Consultation, guidance and motivation of others
		Leadership	Dialogue engagement
			Opinion sharing
			Constructive and creative discussion
			Adjustments of opinion, negotiation and persuasion
	Autonomy	Emotional control	Self-awareness
			Stress tolerance
			Stress management
		Creating confidence	Understanding of identity
			Self-efficacy and optimism
			Self-transformation by new viewpoints and opportunities
		Sustaining action	Proactive behavior
			Accomplishment
			Making good behavior habitual
	Problem solving	Finding problems	Information collection
			Understanding the essence of the problem
			Cause pursuit
		Planning a solution	Goal setting
			Scenario creation
			Plan evaluation
			Risk analysis
		Implementing the plan	Action taking
			Modification and adjustment
			Verification and improvement

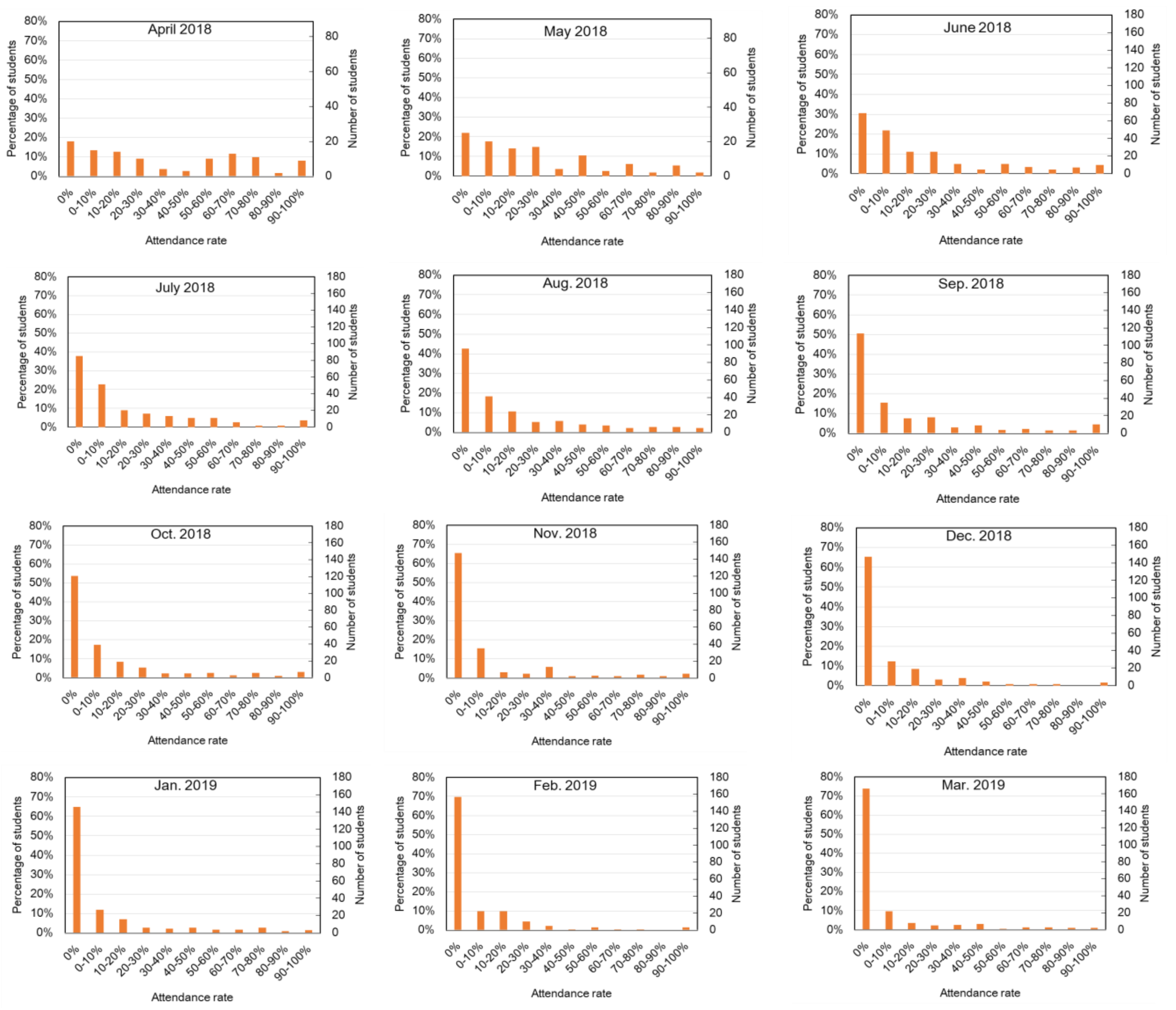

Figure 1 Attendance Rate Distribution per Month

trying to make a learning community in each class were not effective tools for motivating greater attendance. The creation of student communities of OECT in each class might have been more effective when the attendance rate was high to begin with, but when the attendance rate of the whole class tended to decrease, the students' nature gravitated toward conforming to the easy way out with their peers.

Next, Figure 2 shows the change in attendance rates for overseas training participants in September 2018, overseas training participants in March 2019, and non-participants. The September 2018 overseas training participants maintained a high OECT attendance rate in May-August before their overseas training; but, after that, their attendance rates became the same as that of non-participants. Although their goal setting for the near future seemed effective, it appeared to have no positive effects for their interest, or lack of interest, in long-term self-study. From interviews, we learned that students who started OECT with distant future goals, such as acquiring English-speaking skills for future jobs, could not keep up with OECT study for the long run. On the other hand, the OECT attendance rate of the March 2019 overseas training participants rose in August and September and stayed consistently above average until

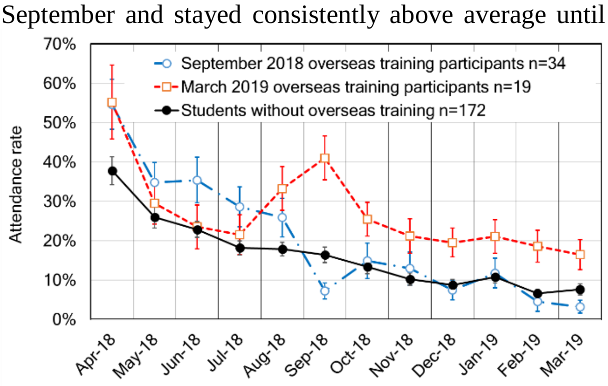

Figure 2 The Relationship between Attendance Rates and Overseas Training

their overseas training. One reason for this trend in participation was that we informed the students that they might not be able to participate in overseas training if their OECT attendance rates were low and if we had too many applicants for the spring programs. However, as soon as the overseas training participants for the spring had been determined in October, their attendance rate started to diminish. Once again showing evidence that having clear goals for the immediate future can only be effective for maintaining the OECT attendance rate in short periods, such as for one to two months. During interviews with the students, who had the top 10 highest attendance rates during summer vacation, we learned two reasons for their commitment to OECT: "I enjoy English conversation" and "I have decided a time for OECT in my daily routine." For many students, who are new to OECT, they need to continue OECT for at least three months to understand the conversation and enjoy it. Unfortunately, the average student's tendency is not to stay at it for three months.

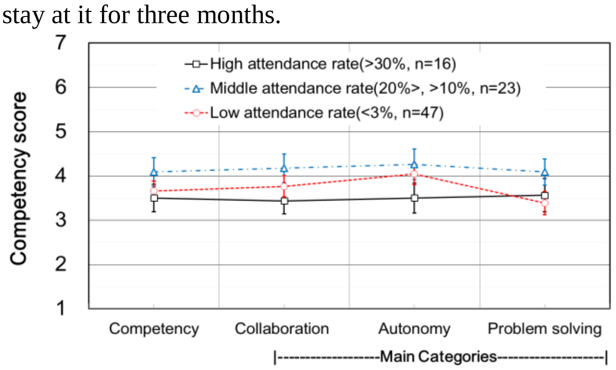

Figure 3 The Relationship between Competency Scores and Attendance Rates

Figures 3 to 5 show the overall competency scores on the PROG test achieved by 47 students with an annual attendance rate of under 3%: A "Low attendance rate," 23 students with an annual attendance rate of 10% to 20%: A "Middle attendance rate," and 16 students with an annual attendance over 30%: A "High attendance rate." By comparing the scores in the "Main Categories" in Figure 3, no significant differences among the competencies in relation to differences in attendance rates can be found. The average competency score of all Akashi College students in their 2nd to 4th year is 3.5 points (T. Hiraishi, et al., 2018), which is nearly the same as the competency scores of these students.

Figure 4 shows the high attendance rate group with a low average score for the "Cooperation" subcategory. In other words, students in the high attendance rate group are more likely to be the types of students who are not affected by their surroundings and like to work individually. In the Specific Characteristics (see Figure 5), there was a significant difference in "Goal setting" that showed the students with high attendance rates to tower over the others, even though the same students had low scores for "Self-efficacy and Optimism." One would expect that there would be a correlation between "Accomplishment" and "Making good behavior habitual," in relation to the attendance rate, but there was no significant difference between the High attendance rate students and the other students here either. It is presumed that if the students cannot achieve PROG scores of 3 points or more in these specific characteristic competency levels, then they cannot reach the threshold of competency for SAL endurance. These data show that very few students can continue OECT at home, while relying on their current individual levels of competency. In order to improve attendance rates, teachers and/or small support group organizers must provide conditions through which they can study continuously and build their SAL endurance.

Finally, Figure 6 shows the attendance rate change of students in one of the aforementioned support groups. Student A applied for a "Tobitate" study abroad

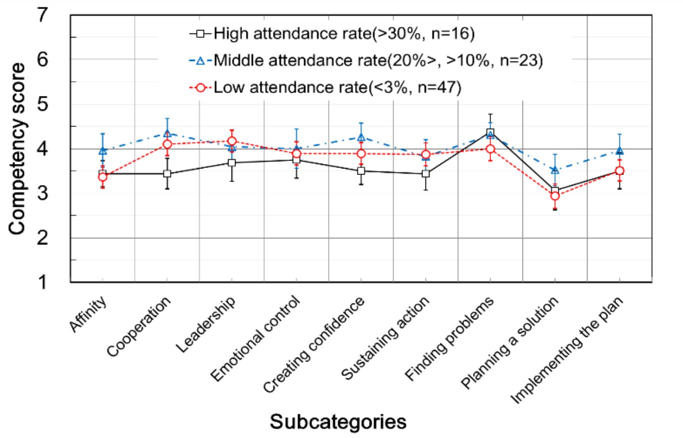

Figure 4 The Relationship between Subcategory Competency Scores and Attendance Rates

scholarship in January 2019 and was approved in April 2019. Tobitate is a scholarship program provided by Japan's Ministry of Education, Culture, Sports, Science, and Technology (MEXT) that aims to help eager and capable Japanese youth to take their first steps toward studying abroad. Student A needed communication skills for his internship in the USA from August to September 2019, so he decided to take OECT every morning at 8:30, and he established a regular meeting place. His average OECT attendance rate from June 2018 to March 2019 was 40%, but from April 2019 until his departure for the US, and upon his return from the US until present day, his attendance has been over 90%.

Student B was the leader of the Student Ambassadors, an international student outreach group, at Akashi College, and he wanted to improve his English conversation skills; but, prior to joining the group, he could not continue OECT on his own, so the author invited him to study in the support group. Soon thereafter, he started OECT in the same room at the same time with Student A. That was October 2019. Since then, Student B has maintained an attendance rate of over 80%.

Student C planned to go to the United States for an internship in September 2020, so he also decided to join

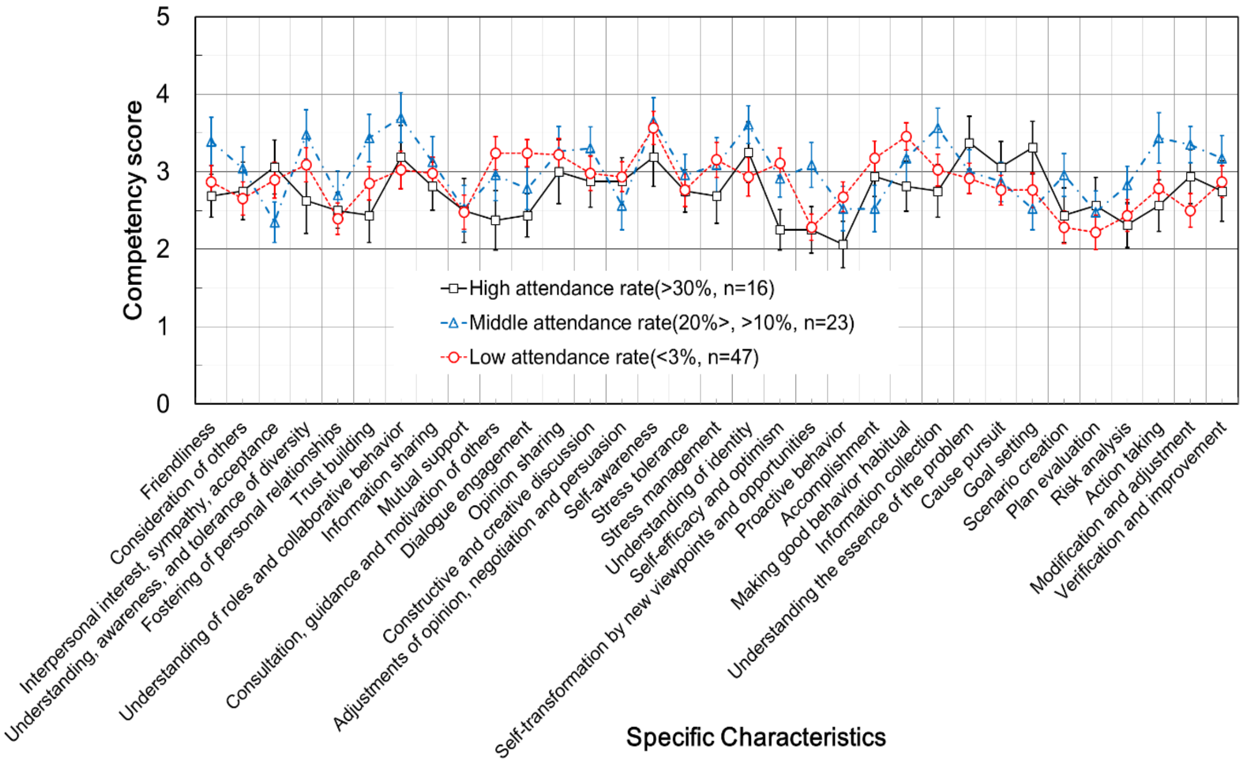

Figure 5 The Relationship between Specific Characteristic Competency Scores and Attendance Rate

the group and start lessons from October 2019. He said in our interview that his high attendance rate in August to September 2018 and in March 2019 was due to his decision to take lessons every day during long vacations, when he had more time.

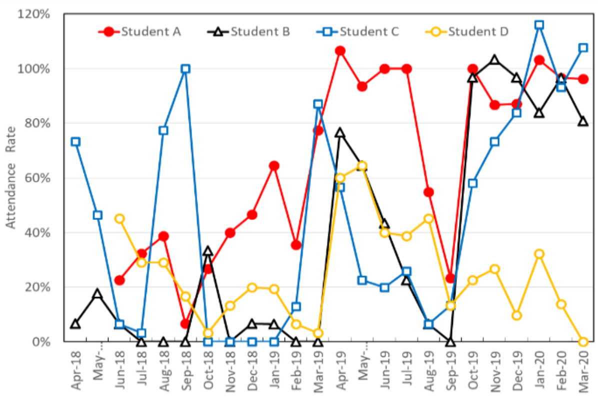

Figure 6 The Attendance Rate in the Support Group

Student D was later invited by his friend, Student B, in December 2019, but he was not able to maintain a high attendance rate. His attendance rate was high at starting point, and then it declined over time as with many other students. He could not continue the lesson because the promise between he and his friend was not strong.

During the spring break from February 22, 2020 onward, the time and place were not fixed, but student A, B, and C have continuously studied online and seem to have made this good behavior habitual. As such, for these three, starting OECT required some incentives; but continuing it beyond the semester and for more than a few months required the initial fixing of a time and a place and an ongoing promise to someone with whom they valued maintaining a good reputation.

Conclusions

The following conclusions can be made from the PROG test results and the attendance rates of OECT students over a 2-year period:

1) Motivation to attend is generally effective for only a short period of about one month.
2) There were no significant differences in overall competency scores with respect to attendance rates.
3) Very few students can continue OECT at home by relying on their individual motivation and competency.
4) The students require a fixed time and place of study with a commitment to someone whose faith will be placed in their promise to get the job done in order to develop their SAL endurance.

Therefore, for the purpose of increasing the attendance rates of OECT, it is recommendable to create small support groups for setting goals and carrying them out together. By doing so, this may sharpen the very study habits which are most relevant to enhancing the students' future experiences with online SAL and lifelong learning. As such, it is important for teachers to teach students how to learn on their own and how to acquire self-coaching skills. Ideally, this can be achieved by creating support groups that will help students

- set clear and achievable short-term goals
- commit to OECT
- acquire and continue using self-coaching skills

Education tools are changing radically, and there are many ways to learn with ICT. Therefore, the ability to endure using these tools of learning on one's own is growing even more important than before.

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System Development Training Using Small Satellite Kit “HEPTA-Sat” for Education

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Abstract

In this paper, we will report the content of the experiment of "System development training using small artificial satellite kit 「HEPTA-Sat」" at National Institute of Technology, Kagawa College. HEPTA-Sat is a small satellite training kit developed by Nihon University. It is equipped with three primary subsystems – EPS, CDH and Communications, supported by a 3D-printed structure and sensing elements. Students can perform operation verification in subsystem units and integration tests combining the entire system. Specifically, in this training, students perform three tasks. First one is the "Operation verification for each subsystem". Second one is the "Operation verification for the whole system". And last one is the "Design and implementation of mission". Students can learn system development through the experiments, such as "How each subsystem works" and "How to integrate subsystems into satellites". And in the mission design, which is an advanced issue, it is also possible to design a mission by actually thinking about "What will you do if you make a satellite?". It is a good study for students to design missions considering actual situations. We had evaluated them with reports. We had considered two points. 1. Were the experiments performed systematically and explain the findings obtained in the experiment? 2. Did they set appropriate missions? We have evaluated the effect of this experiment with a questionnaire prepared by the author.

Keywords: *system development training, small artificial satellite, HEPTA-Sat, training kit*

Overview of HEPTA-Sat

HEPTA-Sat is a training tool developed by Prof. M. Yamazaki from Nihon University in Japan for hands-on study of satellite-engineering (Yamazaki, 2016a). By taking a course with this kit, students can learn the basic subsystems of satellite including structure, electrical power supply, command and data handling, communication, ground station, and sensors as well as learn how to integrate those subsystems to create a working satellite as a whole.

According to the textbook(Yamazaki, 2016b), HEPTA-Sat is composed of six different subsystems each performing a different function. The characteristics of this training kit are

- Each components can easily be taken apart and reassembled, allowing users to practice integrating many times.
- All the hardware and software are modularised into a reusable system so that users can focus on integration and make full use of a short lecture time.
- System with high extendibility, allowing users to add on to the system to test their own mission that they design.
- Includes a textbook that covers a wide range of knowledge necessary for satellite engineering.

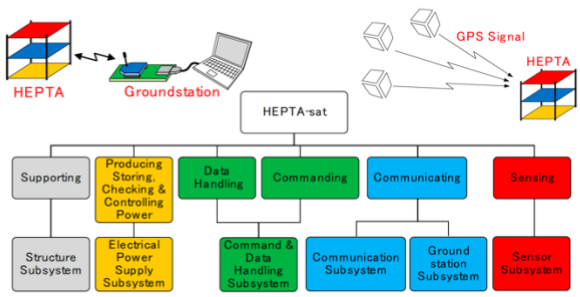

Figure 1 Function and Physical Architecture

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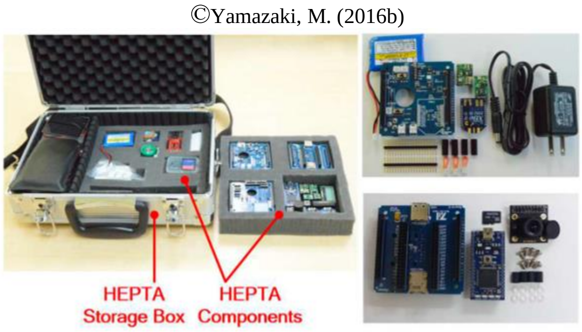
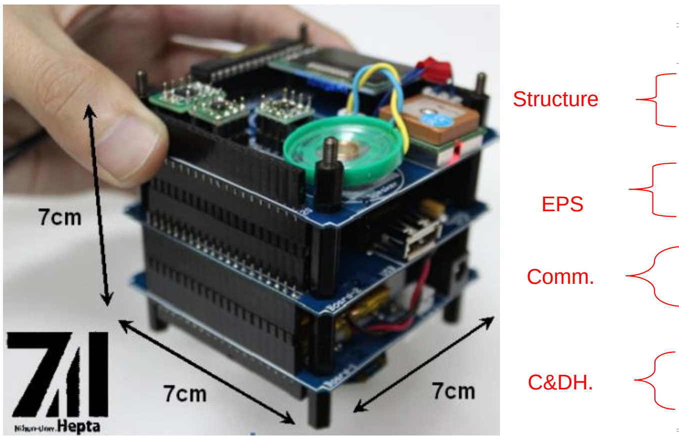


Figure 2 HEPTA Kit ©Yamazaki, M. (2016b)



Specification	Value
Form factor	7 x 7 x 7 cm^3
Mass	180g
Power generation	5.0V 0.8A, 3.3V 2.0A
Power consumption	1.2W(MAX)
Battery	3.7V, 1000mAh
Uplink/Downlink	2.4GHz
Communication Range	400m
Programing Interface	USB
Device Interface	SPI/I2C/UART/AD
Operating Frequency	100MHz
Data Storage	4GByte

Figure 3 Specification of HEPTA-Sat ©Yamazaki, M. (2016b)

Hands-on Training with HEPTA-Sat

It shows an example of the actual flow of satellite development in Figure 3. On the left side of the figure, the requirements are broken down and subdivided down to the component level, the smallest unit of the satellite system. In Hands-on Training, these functions are derived from the determined mission. It clarifies the requirements for the corresponding subsystem. Students will learn how to select and design systems, subsystems and components from the identified requirements. In addition, they learn the role and behavior of satellite systems, subsystems and components through lectures and textbooks. The right side of the figure shows how components and subsystems are integrated into a system through assembly, integration, and testing. At each stage of assembly, integration & test, disassembly and integration of software and hardware, students work while confirming that the required ones are made. Through their work, they can learn how to verify and validate the system.

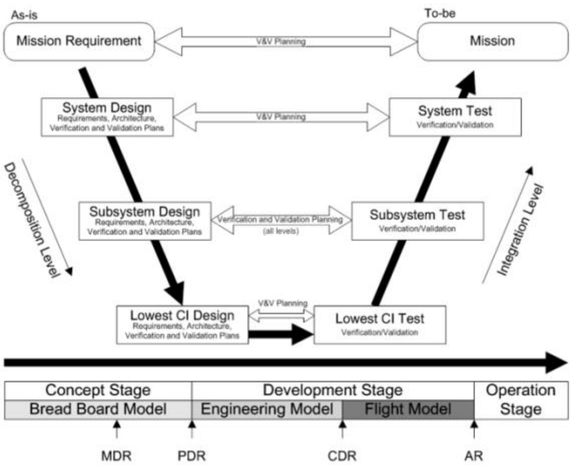


Figure 4 Satellite development process
©Yamazaki, M. (2016b)

Teaching Method in "Engineering experiment / Practice I" and "Engineering experiment / Practice II"

This subject is an experimental subject for first-year students of Advanced course. Table 1 shows the lesson plan. In this course, three experimental themes are conducted in groups with 4-5 people. In the "Practice using HEPTA-Sat", 4 out of 15 lectures (24 hours) are allocated. Under the advice of the faculty members and technical staff, the students voluntarily conduct experiments according to the textbook (Yamazaki, 2016b.) They analyze and examine the experimental results in detail. And a technical report has to be prepared and submitted through sufficient consideration.

The purposes of this subject are the following five.

(1) Deepen your knowledge of electrical and electronic and information engineering through experiments.

(2) To become skilled at the operation of various equipment.

Table 1 Lesson plan of Engineering experiment / Practice I

Week	Class content / method
1 – 7	Robot competition using LEGO Mindstorms
8 - 11	Network design and construction
12 - 15	**System development training using the small satellite kit "HEPTA-Sat" for education**

Table 2 Lesson plan of Engineering experiment / Practice II

Week	Class content / method
1	Advanced challenges for embedded technology（Guidance only）
2 – 6	Audio amplifier production
7 - 9	Software code review
10 - 15	Advanced challenges for embedded technology

Table 3 Experiment schedule

DAY	TIME (rough indication)	EVENT	
DAY1	10:30 - 10:40	Opening Session	Explanation of purpose
	10:40 - 11:00	Introduction	Lecture
	11:00 - 12:00	1st Session	EPS subsystem Assembly, Integration & Test
	12:00 - 12: 50	Lunch Break	
	12:50 - 14:20	2nd Session	EPS and C&DH subsystem Assembly, Integration & Test
	14:30 - 16:00	3rd Session	C&DH and Sensor subsystem Assembly, Integration & Test
DAY2	10:30 - 12:00	4th Session	Comm. & Sensor subsystem Assembly, Integration & Test
	12:00 - 12: 50	Lunch Break	
	12:50 - 14:20	5th Session	Grand station subsystem Assembly, Integration & Test
	14:30 - 16:00	6th Session	ALL SYSTEM Integration & Test
DAY3	10:30 - 12:00	7th Session	Mission design
	12:00 - 12: 50	Lunch Break	
	12:50 - 14:20	8th Session	Mission subsystem (program) Integration & Test
	14:30 - 16:00	9th Session	Field Test and summary

(3) To acquire the ability to analyze experimental results accurately and to consider them based on engineering theory.

(4) To acquire the experimental results properly, acquire the judgment ability and the execution ability that one should make at each stage.

(5) Create a technical report that uses technical terms and is well-structured. And develop the communication ability to fully convey the experiment contents and conclusions.

This lecture is a subject offered in the first semester. And we have another class named “Engineering experiment / Practice II” in second semester. In that class, more three experiments are conducted（Table 2）. The theme with two instructors has twice as many hours as the theme with one instructor.

Our students learn advanced knowledge of electricity and information technology with these two subjects.

Experiment schedule and contents of "HEPTA-Sat"

It shows the experimental schedule on Table 3. On the first day, an instructor gives a lecture on the purpose of the experiment and how to proceed the experiment. After that, students form a team of 2 or 3 people. Then each team starts the experiment. This experiment consists of 9 sessions. In sessions 1-5, all teams assemble and integrate and test each subsystem. In the sixth session, they integrate all subsystems and complete the producing of “HEPTA-Sat”. The third day is an experiment on a satellite mission. In the seventh session, each team design a satellite mission. In the eighth session, they develop a program for their designed mission. In the ninth session, all teams conduct field tests and then summarize the experimental results.

The students use several class materials which are a "Parts List", a "Textbook", a "Technical Appendix" and a "Verification matrix". At First, they use the parts list to check for parts in HEPTA-Sat. If any parts are missing, they notify the instructor. Then, they conduct the experiment, referring to the textbook.

Questionnaire evaluation

The experiment has conducted 3 times in 3 years. Since I have improved the experiment method every year, it seems that the students who conducted the experiment in the third year had the highest educational effect. Therefore, I gave a questionnaire for last year students to confirm the educational effect. The questionnaire items and results are as follows.

1. Do you think that you could learn "the mechanism of each subsystem of artificial satellites " through this experiment?

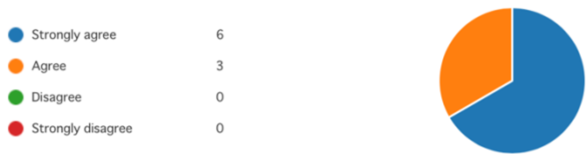


Figure 5 The result of Question 1

2. Do you think that you could learn about "the mechanism of the whole system of artificial satellites" through this experiment?

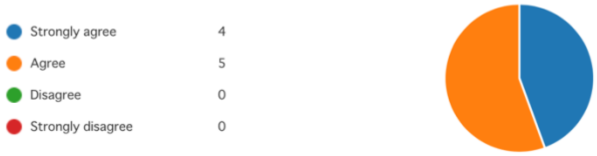


Figure 6 The result of Question 2

3. When you designed the mission, did you discuss the mission with your team members?

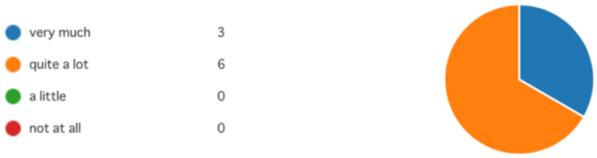


Figure 7 The result of Question 3

4. Do you think that the mission you designed is based on the assumption of an actual mission in space?

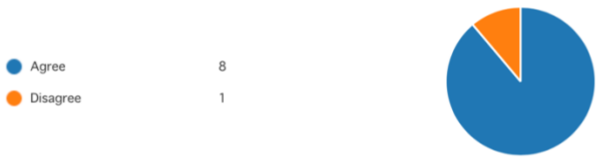


Figure 8 The result of Question 4

5. Do you think this experiment will be useful for learning "manufacturing of satellites"?

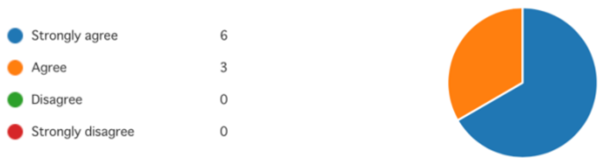


Figure 9 The result of Question 5

6. Do you think this experiment will be useful for learning about "system development"?

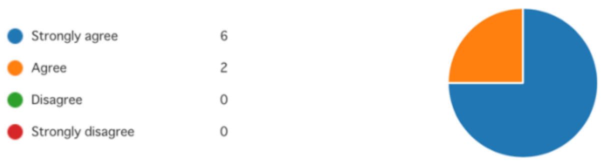


Figure 10 The result of Question 6

From the results of questions 1 and 2, it can be seen that most of the students were able to learn about the mechanism of each subsystem of satellites and the overall system. From questions 3 and 4 it can be seen that the students are considering a mission, and that it is related to a real space mission. From questions 5 and 6, the students replied that this experiment was useful in learning "development of artificial satellites" and "system development". All questions were the high score.

From these results, It is able to consider that this experiment was successful.

Analyzing the student's mission design

Next, I would like to analyze the student's mission design of three years. In the first year experiment, they only did a desktop mission design. Their desktop design examples as follow.

[Question]
What functions would you like to implement on your satellite? And what will the functions do specifically?

[Example Answer 1]
There is no dust in the vacuum space. So it is suitable for shooting. Therefore, we photograph other planets (moon, Jupiter, sun etc.). It uses a communication function and an acceleration sensor. The direction of the body is controlled by changing the value of the acceleration sensor by the communication function.

[Example Answer 2]
It communicates GPS data between satellites to prevent collisions with other satellites. It continues to send GPS data. If it approaches another satellite, it moves away from that.

[Example Answer 3]
It performs Morse communication with other satellites with LEDs. It makes Morse communication by blinking the LED in order to be recognized by other satellites.

These answers have free ideas and I felt very interesting. But unfortunately, I supposed some of the answers were impossible to achieve in universe. For example, the accelerometer cannot change the attitude of the satellite. And it also did not specify where to send GPS data.
So, in the second year experiment, I have instructed my students to actually implement the proposed function on HEPTA -Sat. Their answer examples as follow.

[Example Answer 1]
Mission : Start shooting when HEPTA -Sat tilts
Operation : Normally, the sensor attached to HEPTA is used for observation. When the HEPTA is tilted, the camera shoots.
Explanation and consideration : When the value of the accelerometer exceeds 9m/s_2, the camera shoots and displays a message on the liquid crystal display. The advantage of this function is that if there is an unexpected situation to HEPTA -Sat, it can be recorded with a camera device.

[Example Answer 2]
Mission and Operation : Until a command from the ground station arrives, the slope, acceleration, GPS data, and voltage value of HEPTA-Sat are continuously

transmitted as information. When the command “a” is received from the ground station, the voice module speaks “Command OK”. If the command is other than a, “Command Error” is displayed on the liquid crystal display.
Explanation : We implemented the function by combining the basic tasks learned on the first day and the second day.

Although it was good that the function was actually implemented, but mission idea was little bit simple. It was just a mission that integrated the basic programs. Therefore, I instructed 2 rules the students who conducted the experiment of the third year. First one is "Consider about space mission with your team members" and Second one is "To implement the function on your HEPTA-Sat." The answer examples of third year as follow.

[Example Answer 1]
Mission: Start shooting when HEPTA -Sat tilts
Assumed situation:
- HEPTA-Sat is in space.
- The focus of the camera is at infinity.
- The captured image is saved on the SD card.
- It does not send the captured image to the PC.

Explanation: Since HEPTA-Sat is operated in space, a gyro sensor is used for attitude determination. It is because using an accelerometer makes gravitational acceleration on the earth, which makes development testing difficult. Since it is operated in space, the subject is very far away. Therefore, the focus of the camera is set to the point at infinity. The image data is 200KB, and it takes about 5 minutes to send to a PC. Therefore, we abandon the data transmission and save it on a SD card.

Result:
The image is out of focus because of the focus setting at infinity. There were no problems. It took a picture when the posture was stable. The mission was successful.

Figure 11 Image taken by HEPTA-Sat

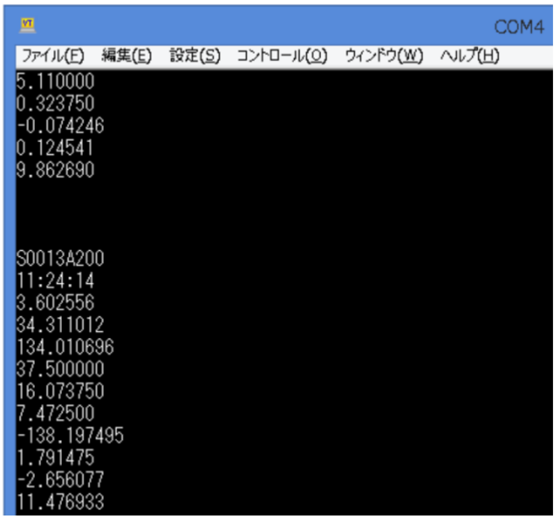
[Example Answer 2]
Mission and Concept: Most micro satellites (CubeSat) has adopted two or more types of communication methods. It sends "housekeeping data" to the PC with XBee. Then save the "mission data" to the SD card.
Explanation:
1. Acceleration, gyro, GPS and battery data are housekeeping data. Especially for GPS data, the current time (JST) and altitude are acquired in addition to latitude and longitude.

2. As the mission data, a image is saved on the SD card. The image is taken when the acceleration applied to the satellite exceeds 10 m/s^2.

3. The HEPTA-Sat mode is switched according to the HEPTA-Sat battery voltage.

Result: Figure 12 shows the XBee data sent by HEPTA-Sat. This data is the header specific character string, time, battery voltage, latitude, longitude, altitude, gyro (3 directions), acceleration (3 directions) from the top.

Figure 12 XBee data sent by HEPTA-Sat



Discussion

Did you notice that Answer Example 1 in second year and third year are very similar? And answer example 2 in the second and third year is also similar. This may be due to the limited HEPTA-Sat sensors available. However, in the answer example of the third year, you can see that the mission is considered more than in the second year one. From the mission explanation, it can be seen that the third year’s mission are considering using in outer space in detail. Furthermore, it can be confirmed from the result of the questionnaire too. The result of Question 3 shows that they have discussed the mission with their team members. And the result of Question 4 shows that it is supposed to use in universe. Therefore, I think the results of the 3rd year’s mission design is at a sufficient level.

Conclusions

I have introduced hands-on training using HEPTA-Sat to Engineering experiment / Practice I of the Advanced course in Kagawa college, and summarize the results of the experiment for 3 years. From the contents of the experiment report in the third year and the questionnaire to the students, it was confirmed that the students considered the mission assuming the use in space. In addition, from the results of the questionnaire, I confirmed that the students have learned about satellite development and system development by this experiment. My future task is to prepare many sensors to improve the flexibility of mission design. It is also useful to refer to the results of other teaching materials. For example, I have been participating in “KOSEN Space Collaboration”. KOSEN Space Collaboration has been holding aneducational event called KOSEN Space Camp, everysummer since 2015 (Wakabayashi et al., 2019a; 2019b; Kitamura et al., 2019). At Space Camp, there are groupcompetitions and practical training courses conductedusing teaching materials that have been developed by KOSEN Space Collaboration. Therefore, I would like to more improve the experiment by referring to these results.

Acknowledgments

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TEACHING METHOD AT NIT COLLEGE TO DEVELOP FUTURE ENGINEERS THAT COPORATE R&D WANTS

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Abstract

Corporate research and development (R&D) lead a hybrid development involving different fields. This paper proposes for improving the teaching methods at National Institute of Technical College (NITC) to develop engineers with the qualities that R&D department wants. Corporate R&D requires NITC's graduates to become the engineers in the next-generation. Requirements to become the engineers in the next-generation are the ability to develop new technologies with innovative ideas and acquiring advanced knowledge of the specialized field of the company and studying of another field also. Corporate R&D requires them with the ability to find challenges by themselves and to plan the project road map for solving the challenges. Under the present conditions, lower grade education in NITC involves the mastery of basic knowledge by lectures and acquirement of utilizing method of knowledge by Project-Based Learning (PBL). The upper grade education in NITC involves the acquisition of advanced technical knowledge. The purpose of the PBL course is to learn techniques to solve problems. If we improve the educational content of the PBL, then the PBL course trains the engineers with the ability to plan a project to embody to solve the problems. Improvement of PBL educational contents is below. It is suggested that PBL project planning promotion training be conducted in three stages. In stage # 1, teacher provides guidance on how to search for issues and how to plan a project. In stage # 2, student-based training on searching issues from small themes and trials of project planning are performed. Stage # 3 is practice, where the student cuts out a small theme from school issues. Examining the need for conditions is the most important practice. After stage #3, it is the actual training with limited conditions. The abilities that companies demand from students in NITC are the ability to solve problems for R&D and keeping the willingness to learn, as qualities to become the engineers of the next-generation. In order to respond to the demands of companies, I propose the fixing of basic knowledge and the development of the problem-solving skills using PBL in the NITC's education.

Keywords: *PBL, three stages training, NITC's education, next-generation force, problem-solving*

Introduction

As technological innovation progresses, the time from product development to market launch is becoming shorter. Companies have come to want practical engineers who are capable of short-term development. In response to the demands of companies, education in technical colleges introduced Project-Based Learning (PBL), which is a hands-on comprehensive learning in addition to classroom lectures. There are various ways to proceed with PBL, and various educational institutions have begun to try various methods, not just technical colleges (e.g., Roessingh and Chambers, 2011; Beacham and Shambaugh, 2007; Karaca, Karahoca, D. and Karahoca, A., 2016).

As customer tastes diversify, corporate R & D is shifting to complex development that includes different fields in order to increase added value. This paper describes human resources and education that companies want, and proposes how to promote PBL education of NITC in order to develop human resources.

Human resources and education required by corpotate

I have been conducting research and development work for 40 years in the R & D department of a company, and became a technical college teacher. Based on work experience in a company's R & D department, we describe the human resources that the company's R & D department wants, and the education they want.

The company's R & D department wants the following two types of development force.

1. Ready force
2. Next-generation force

Ready force is an engineer who can get into the front line of R & D and develop competition if he / she learns general corporate ethics. Mid-career hires, Ph.D. and M.S.

are the engineers under ready force. Those who can be ready immediately are engineers who can perform R & D immediately after joining the company, conducting research and development in the field of research that was in charge of the graduate university's laboratory or a similar field. The skill required for an engineer as a ready force is to have basic knowledge and academic ability, and have high specialized knowledge and applied ability.

The next-generation force is an engineer who has a training period to cultivate applied power in the R & D field and also has knowledge in different fields, and who can develop new technology in a wide field. Next-generation force is for college graduates and B.S. The skills required for engineers as the next-generation force are to have basic knowledge and academic ability, to have the energy to stand up to new things, and to have creativity. Figure 1 shows an image of development elements in compound development. Mixed development is required to proceed in a form that includes different fields in addition to specialized fields and near non-specialized fields. It is required in multi-discipline development to have knowledge and application in different fields. Many engineers often do not have experience with different disciplines. Engineers involved in multi-disciplinary development are required to have the skills to create how to proceed with development, including technologies in different fields, and to estimate what kind of results can be obtained.

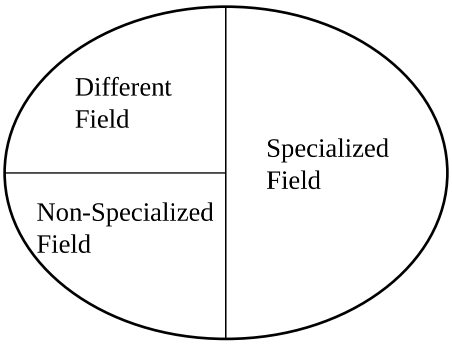

Fig.1 Image of development elements in compound development

An example is the technology for increasing the recording density of HDDs. Magnetic recording in a magnetic disk drive is a method of magnetically recording on a recording medium called a magnetic disk by using an element called a magnetic head that converts current based on the information to be recorded into a magnetic field. When the recording density increases, one magnetization information holding area that is reduced, the magnetic of energy of the lower. The temperature of the environment activates the molecular motion, and the phenomenon that the magnetization information magnetically recorded on the magnetic recording medium disappears occurs. It is necessary to improve the coercivity of the recording medium so that the magnetization does not disappear even when the molecular motion is activated.

The recording medium coercivity by enhanced, normal magnetic head according to the recording magnetic field became difficult. A method was devised in which coercivity was weakened for a short time and magnetic recording was performed with a magnetic head.

One of the methods is to perform magnetic recording by abruptly raising the temperature at the local position where magnetic recording is performed, thereby weakening coercivity. After magnetic recording, the temperature is lowered to increase coercivity.

Techniques in different fields are being introduced to increase the temperature of the local portion of the recording medium. Different fields technique for magnetic recording of a magnetic head element to generate a plasmon by laser light in the vicinity, topically magnetic recording medium for high-temperature portion to produce is that.

At the time of development, magnetism and laser heating were not related technologies in the fields. The laser beam and the plasmon heating which are the technology to meet the demand, rapidly heat a narrow place. The technology was conceived to improve the magnetic recording density.

Although it is a technology in a different field, it becomes a cooperative technology by selecting the application method. There is a long-awaited human resource who has the ability to identify technologies in different fields that can be cooperative technologies.

The education for the next-generation force desired by companies is as follows.

1. Acquisition of basic knowledge and academic ability
2. Cultivate mental strength to stand up to new technologies in different fields
3. Development of ability to examine given conditions in development
4. Fostering the ability to create or speculate on goals

Engineers who have acquired the above skills at the time of joining the company will become engineers with a wide range of application abilities and perspectives for technologies in different fields. They can make a great contribution to corporate development in a short period of time.

Current state of NITC education

In order to produce excellent human resources to companies, technical colleges provide education that emphasizes the following two points.

1. Familiarity with theory
2. Nurturing innovative creativity

Familiarity with theory is the acquisition of basic and specialized knowledge through knowledge education through classroom learning and experimental training. Experimental training is conducted within the scope of knowledge education. The experimental training is outside the scope of knowledge education, so new awareness cannot be expected.

The training of creativity is the acquisition by hands-on education. In recent years, PBL has been introduced as a new trial, which is a comprehensive experience-based learning. PBL is a comprehensive learning method that is close to project management, such as how to set a problem for a project and formulation of a problem solution. In PBL, students can foster the ability to combine and use multiple knowledge acquired through classroom learning, experiments and practical training to solve problems, and develop the ability to promote projects to embody the created things. The current PBL cultivates the ability to combine and use multiple pieces of knowledge, but it is difficult to have experience in referring to different fields.

Suggestions for NITC education

Basic knowledge and academic ability are the means to pursue the truth and promote understanding, so acquisition is important. Basic knowledge cannot be applied. It is necessary to make efforts to accumulate specialized knowledge by using academic ability on top of basic knowledge. Accumulation of specialized knowledge as an engineer cultivates the ability to understand the truth and enables creation. If you can create it, you can think of the means of application for its realization. Successful realization is the driving force that seeks higher success and broadens the field of view including different fields. Failure of realization encourages perspectives in different fields.

PBL is a learning method that uses basic and specialized knowledge as the core to foster applied power. If there are few opportunities for PBL, there is a possibility of becoming a person who cannot apply it despite having a lot of knowledge. Even if the truth is understood, it is difficult to materialize. The experience of PBL cultivates a wide range of perspectives and insights to be realized based on basic and specialized knowledge. At the same time, the experience develops the ability to apply technologies in different fields.

PBL that fosters pioneering spirit in different fields

PBL fosters a pioneering spirit in different fields. It is assumed that the theme of PBL has been set as a problem related to life in the residential area. The promotion of PBL will contribute to the community and will be a successful experience in society. PBL promoters who have experienced success will find the fun of research and development based on multifaceted viewpoints and ideas. At the same time, they cultivate a pioneering spirit in different fields, seeking high-quality success. I think that incorporating programs that foster pioneering spirit into the PBL is the path to the human resource development that companies want.

A person who has no PBL experience cannot promote PBL. In order to train PBL promoters while attending NITC, I propose the following three steps.

Step 1 PBL promotion guidance by a teacher or PBL promotion expert

- How to find an assignment
- How to assemble the project and how to proceed
- Result reporting and application method

Step 2 Simulate promotion of once-promoted issues as a small theme

- Training for task search
- Trial of project assembly and promotion

Step 3 Practical promotion with the theme of school issues

- Multiple perspective training
- Consider the need for conditions along with solutions
- Examining the need for conditions

The purpose of Step 1 is to give direct guidance to students and make them accustomed to PBL promotion. Step 1 gives themes that have been implemented and are listed as successful examples. The instructor teaches students from the stage of studying assignments. The instructor will show the process of setting the theme of PBL while giving guidance on the method of studying the task and how to organize the task. As an instruction to the students, the instructor will analyse the issues from various perspectives on the theme, and have them be summarized by category. Ask them to find a causal relationship for each classification and find the root cause. In many cases, it is not possible to view from multiple directions, and only the perspectives in one direction are analysed deeply. Teachers give hints from multiple directions and let them experience multiple perspectives. Based on factor analysis, the instructor teaches how to assemble a project for solution and how to proceed. Once the results are available, the instructor will teach how to report and apply the results. In Step 1, you can experience basic PBL promotion methods.

Step 2 aims to promote the challenges already promoted by the students themselves and to experience success. The leader oversees the situation in which the student plans and promotes the project. Leaders provide guidance only when guidance is required. Students will get results at PBL and experience success. Since the instructor has already been promoted, the instructor can grasp the ability of the student to promote by comparing with past achievements.

Step 3 aims to complete the PBL promotion training. The PBL conducted in Step 3 will be targeted at the on-campus tasks so as not to cause inconvenience even if the PBL promotion fails and not to affect the mind of the student. Students will study the issues, analyse the factors, and assemble and promote the project. Leaders will only give advice to avoid failure. Step 3 is a student-led project aimed at new challenges, so a successful experience will give you confidence in promoting PBL. If students utilize the knowledge of the specialized field in the promotion process, they will develop a pioneering spirit outside the specialized field. I will discuss later, “Examining the need for conditions.”

Those who have studied in 3 steps will be involved in PBL of regional cooperation and experience the successful experience of contributing to society. PBL is a good method for comprehensive learning, but it is not completed in one experience. Through repeated experience many times, he will become an engineer who can promote development and research with a broad perspective in different fields.

PBL that develops the ability to examine the need for conditions

Research and development in companies are conducted under given conditions. In the development that broadens the field of view to different fields, given conditions often hinder the abandonment of incorporating different field technologies. The ability to re-examine whether a given condition is really necessary is the first step in embarking on a different field.

The necessity of the conditions shown in step 3 will be described using an example. The necessity of the conditions shown in step 3 will be described using an example. An example for condition examination is shown in figure 2.

Question: A human who has come to the school will enter into the building. Under the situation shown in figure 3, can you predict which behaviour the human will be the next?

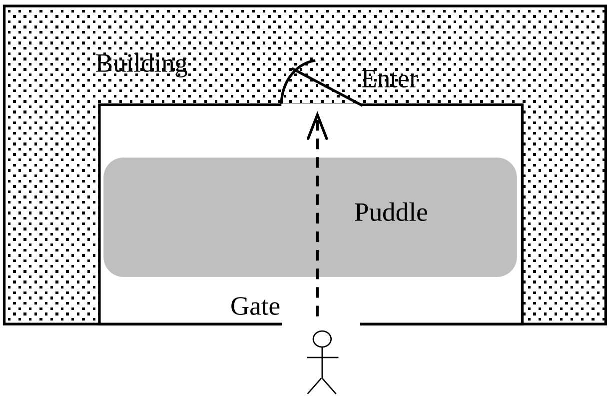

Fig.2 Example for condition examination

A: Go through the puddle towards the entrance

B: Go around the puddle towards the entrance

C: Place a stone in a puddle, cross over a row of stones and head to the entrance

D: Remove water from the puddle and head to the entrance

E: Wait for the water in the puddle to dry before heading to the entrance

F: Come back and start again

Condition 1: Pass through the entrance within 5 minutes.

Condition 2: Go to the entrance without using tools.

Condition 3: Do not get the building wet.

If there are no conditions, all options are good. When the condition 1 is set, the selection branch DEF is considered to be time-consuming, so it cannot be said to be appropriate. Condition 2 also added when set, selection branch C using a tool that rock is eliminated. Condition 3 is also added when set, selection branch A wetted by puddle is eliminated. The correct answer is selection branch B. If you don't have the space to pass around a puddle, selection branch B is virtually impossible. There is no real solution.

Let's examine the conditions. Conditions 1 and 2 are unavoidable as they are direct restrictions on behaviour. The condition 3 is only that it is not necessary to wet the inside of the building, and it is not a regulation that the user cannot walk in a puddle and get wet. Condition 3 is not a necessary condition for the action, and the next action can be created. “Walk through the puddle to the entrance, wipe off the wet areas and enter through the entrance”. It is alleged that a tool for wiping off a wet place violates Condition 2, but a tool for wiping off a wet place is not a tool for heading to the entrance. It is outside the regulation of Condition 2. When conditions 1 to 3 are set, the appropriate action for the visitor is to "Go through the puddle to the entrance, wipe off the wet part, and then enter from the entrance."

PBL is a learning method that does not seek the correct answer under given conditions, but examines the conditions and searches for an appropriate solution. An example is to think outside the scope of a given condition, a tool that does not exist in the given information, and a tool for wiping a wet place. Developing the ability to examine the necessity of conditions is the first step to broaden the perspective of different fields. In the PBL learning process, it is important to incorporate programs to develop the ability to examine the need for conditions.

Conclusions

Corporate will introduce technologies from different fields, create new added value, and introduce them to the market. Corporate is looking for human resources who can proceed with development while considering technologies in different fields.

He mentioned that PBL is effective as a proposal for technical training for human resource development that corporate wants. In order to foster a pioneering spirit in different fields, it was proposed that the PBL curriculum be divided into three steps to provide successful experiences.

There are always conditions in development. Developing the ability to examine the necessity of the condition itself is the first step to broaden the perspective of different fields, not to consider it as a regulation given the condition. I suggested making PBL a practical learning method.

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Cybersecurity Teaching Expert Development Project by K-SEC
- On Organizing of Cyber Range -

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Abstract

Cybersecurity education is essential for society. It is also urgent to fostering students related to Cybersecurity. In this background, the KOSEN Security Educational Community (K-SEC) has launched to accelerate the fostering students who have strong skills in Cybersecurity since 2015. Moreover, the Highly Advanced Cybersecurity for KOSEN (HACK) Project has been launched by K-SEC since 2019. This project has two purposes. One is improving teachers' skills. The other is the development excellent teaching materials based on the skills. If the project achieves two purposes, teachers could foster the students who have excellent cybersecurity skills. This project has two phases. In the first phase, 2019, we will improve the skills of teachers and develop teaching materials. In this paper, we explain our project FY2019.

Five project management members and 30 participants were selected for the project from all over the KOSEN in Japan. The participants aimed to effectively improve their skills and develop teaching materials by constructing a cyber-range, which is a top-down type teaching material. In the training, we participated in hands-on lectures in collaboration with external organizations, lectures, remote lectures, and external cyber range training utilizing the contents of the lectures. Finally, as a culmination, we aimed to complete a training camp for building a cyber range and a teaching material set such as a syllabus.

The evaluation was performed by measuring the effect of skill improvement before and after the training. As a result, the participants' important knowledge and skills in cyber security were improved. Moreover, the effect of the management policy was also examined. As a result, good results were obtained in terms of team effect and appropriateness of training theme and difficulty setting. As the largest deliverable, we have succeeded in developing a cyber range with two different exercise items and established it as teaching materials. It is possible to incorporate it into the classes from the next year. In the first year, we were able to obtain an effective takeover material for deployment in the next year with sufficient validity and justification above a certain level.

In this paper, we evaluate the effectiveness of cybersecurity education and the methodology for teachers in the first phase. Comparing the differences between skill improvement on the first phase and feedback from students on second phase is effective not only for cybersecurity education but also for considering the practical education for KOSEN.

Keywords: *Cybersecurity, Cyber Range, Cybersecurity Education, teaching material, Faculty Development*

Introduction

Cybersecurity education is essential for society. It is also urgent to fostering students related to Cybersecurity. There is a project to learn Cybersecurity systematically is called CyBOK. CyBOK is the project, funded by the National Cyber Security Programme, is led by the University of Bristol's Professor Awais Rashid, along with other leading Cyber security experts CyBOK Project(2019), CyBOK(2019). Awais(2018) et al. explained that CyBOK has five major areas (HUMAN, ORGANISATIONAL& REGULATORY ASPECTS, ATTACKS & DEFENCES, INFRASTRUCTURE SECURITY, SOFTWARE & PLATFORM SECURITY and SYSTEMS SECURITY) and 19 smaller technical areas. Four of the five elements of CyBOK are technical areas. Thus, it is important to learn technical areas for Cybersecurity.

In this background, the KOSEN Security Educational Community (K-SEC) has launched to accelerate the fostering students who have strong skills in Cybersecurity since 2015. Moreover, the Teaching Skill Development project has launched by K-SEC since 2019.

This project has two purposes. One is improving teachers' skills. The other is the development excellent teaching materials based on the skills. If the project achieves two purposes, teachers could foster the students who have excellent cybersecurity skills. This project has two phases. In the first phase, 2019, we will improve the skills of teachers and develop teaching materials. In the second phase, 2020, the course will be developed by giving lectures using the developed teaching materials, the teaching materials will be evaluated, and the teaching materials will be brushed up.

The skills improvement in the first phase is promoted by development learning materials based on top-down approach. In the second phase, we will expound the development of teaching materials. In this period, the teachers' skills and the materials are improved while receiving feedback from students' educational effect. Comparing the differences between skill improvement on the first phase and feedback from students on second phase is effective not only for cybersecurity education but also for considering the practical education for KOSEN.

In this paper, we evaluate the effectiveness of cybersecurity education and the methodology for teachers in the first phase.

Security education method for teacher development

The purpose of the first year of the plan is to improve the skills of teachers and to develop teaching materials by utilizing the improved skills. This project aims to develop a cyber range as a top-down type cyber security teaching material for both faculty and students to achieve effective learning results to take prompt. This approach can be expected to have the effect of actually using it as a teaching material after development, as well as improving the skills of the teachers' selves.

The cyber range (e.g., CYBERIUM, DNP) is a reproduction of the attack target organization's IT system or attacker's terminal in a virtual space disconnected from the Internet, simulating the same functions as in the real world. In attack scenarios, learners can learn cybersecurity attacks while acting as an attacker. In defence scenarios, learners can also learn how to defend his or her organization from an attack by an automatic program, just as in actual cyber-attack. The cyber range developed by a company in Israel, which is the most advanced cyber security country, is used for cyber security education in the military of each country, and we estimate that the educational effect of cyber range is high. The educational method using cyber-range is the best of top-down type education. Therefore, learners can learn the necessary security skills from the experience of cyber-range. Thus, learners can practice more effective learning.

In this teacher training project, 5 members were selected as managements. Furthermore, 30 participants were selected as a participant from 10 KOSEN across Japan by screening. In the screening, the feasibility of future educational development for security education in KOSEN was examined. The management members are charge of selecting the lecture contents and instructing during lectures. At least one of the three participants in the same KOSEN participates in the lecture. The three participants who work from same KOSEN shared information and aimed to improve their skills.

The annual activity plan was examined for the stepwise and effective training of faculty members. Table 1 shows the contents of the actual implementation.

In implementing the above training plan, changes in the self-evaluation scores of the knowledge and skills of participating faculty members before and after the implementation were recorded. The analysis results show the learning effect of the training, and it is possible to link it to the training plan and deployment plan for the next year by examining the validity. In addition, after the completion of all training, a subjective evaluation was conducted on the validity of the plan set this time. From this analysis, it is possible to examine the validity and justification of the plan itself from a viewpoint different from the practical training content. These results are also able to reflect to the next year.

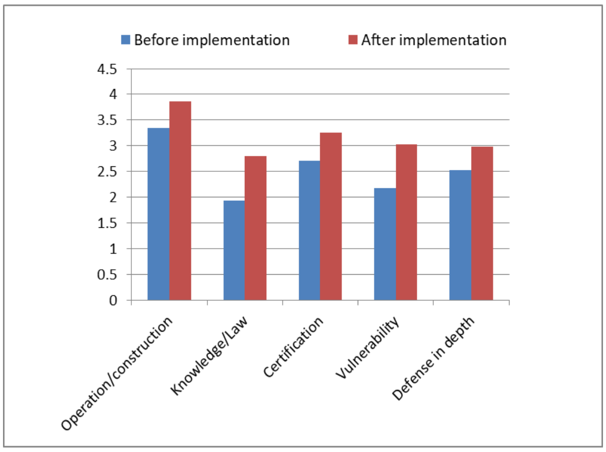

Figure 1. Changes in self-evaluation scores of participating faculty members regarding their knowledge and skills regarding cybersecurity before and after training

Table 1. 2019 Schedule

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	Lecture using a remote conference system 1	● Vulnerability of Linux server 1 (SQL injection)
2019/Oct/3	Lecture using a remote conference system 2	● Vulnerability of Linux server 2 (OS command injection)
2019/Oct/18	Lecture using a remote conference system 3	● Vulnerability in Windows server 1 (Mimikatz execution trace confirmation Kobayashi(2017))
2019/Nov/12	Lecture using a remote conference system 4	● Analysis using Wireshark 1 (SQL injection)
2019/Nov./18	Lecture using a remote conference system 5	● Analysis using Wireshark 2 (C & C Attack)
2019/Dec./2	Lecture using a remote conference system 6	● Vulnerability in Windows server 2 (Investigation of traces of attack execution JPCERT/CC (2017))
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

In addition, we obtained cyber range teaching materials, their syllabus, experimental procedure manuals and instruction books as deliverables.

Evaluation results of educational methods and training plans and deliverables

Figure 1 shows the changes in the self-evaluation scores of participating faculty members regarding their knowledge and skills regarding cybersecurity before and after the training.

The score was self-assessed in 5 levels from 1 to 5. 1 is "no knowledge", 2 is "known", 3 is "teachable (well-known)", 4 is "operational" and 5 is "troubleshooting is possible (higher level operation)".

There are 5 major items of answers, each with 4 or 5 minor items.

The major item "Operation / Construction" includes the 5 minor items such as"OS (Linux / Windows)", "Server (Web server, mail server, DB server)", "Database and access authority", "User and administrator "Access control" and "HTML / Javascript / PHP / CGI". The results in Figure 1 represent the average of self-rated scores for each item. The left side of the graph is the average value before the implementation (21 respondents), and the right side is the average value after the implementation (9 respondents). Similarly, the scores for the four major items before and after the implementation are presented, and the minor items for each are as follows. The major item "Knowledge / Law" consists of four small items such as "Risk causes (physical factors, technical factors, human factors)", "Unauthorized access prohibition law / Personal information protection law", "CVE", "Cyber" and "Cyber kill chain". The major item "Authentication" has four minor items such as "Certificate", "Cookie", "Protocol (HTTP, TCP / IP, IPSec)", and "Basic Authentication". The major item “vulnerability” has five minor items such as “SQL injection”, “OS command injection”, “XSS”, “exploit” amd “security diagnosis, vulnerability diagnosis, penetration test”. Finally, the

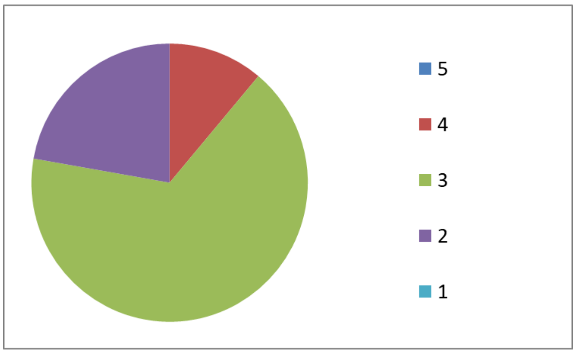

Figure 2. The degree of success of communication for team (5 shows the best participants thought and 1 shows the worst they thought.)

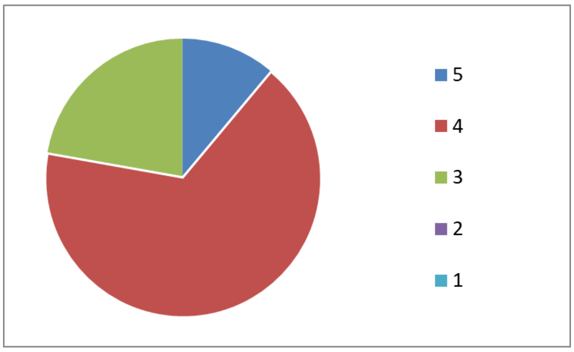

Figure 3. The degree of the effect by team (5 shows the best effective participants thought and 1 shows no effect they thought.)

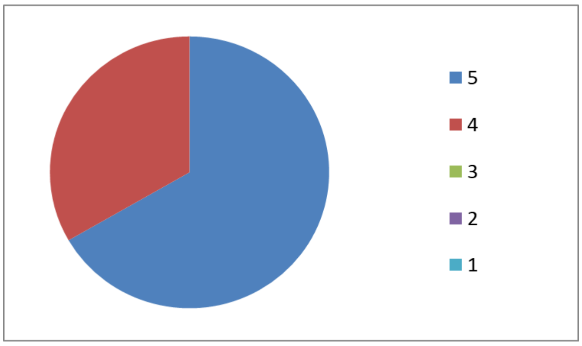

Figure 4. Theme settings; the participants thought (5 shows the appropriate participants thought and 1 shows they thought not appropriate at all.)

major item "multi-layered defense" has five minor items such as "abnormality detection and tampering detection", "firewall", "DMZ", "IDS, IPS", and "WAF". The above items were set based on the experience of the knowledge system SecBoK SecBoK2019 that the management members have referred to so far, and the cyber range training (e.g., CYDER) that they have participated in.

As a result, in all items, the evaluation scores increased from before to after the implementation, suggesting the validity of the training content. In addition, we also separately conducted a questionnaire as to whether or not we felt that our own knowledge / skills were growing, and in Figure 1, the rate of feeling growth was particularly high for the two items of knowledge / law and vulnerability. it was high. This is a result of my own impression and actual growth, which is a useful suggestion for the plan for the next fiscal year and beyond.

Next, as an evaluation of the plan itself, Figures 2-5 show the results of a questionnaire about the degree of information sharing in team participation, the effect of team participation, theme setting, and theme difficulty. All are responses after the training, and the number of respondents is 9, respectively.

Comprehensive consideration about team participation shows that the effect of team participation is acknowledged while feeling the necessity of information sharing. Comprehensively considering the theme, we can obtain the result of appropriate content and difficulty, and it can be said that the plan for the first year was highly evaluated with relevance above a certain level, It became an effective transfer material.

One of the purposes of this project was the development of cyber-range, which is a top-down type cyber security teaching material, and it was completed as a deliverable after the training plan of the first year. The contents are as follows.

(1) Unauthorized access to the educational system

Establish a pseudo server that is similar to the academic affairs system that manages student grades. This server has a vulnerability that allows you to sign in without a password by SQL injection, and a user can exploit the vulnerability as an intruder and break into

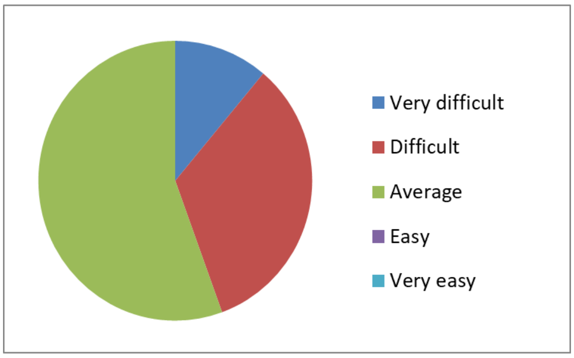

Figure 5. Difficulty of Theme

the educational system. Further, after the intrusion, it is possible to experience the typical illegal operation of the intruder, such as checking the user information and elevating the privilege, falsifying the results, and setting a back door.

(2) Intrusion into the Web server

Establish a vulnerable Web server in the same network. As an intruder, the user finds a Web server in the same network by host scan and port scan. Since the web server uses Wordpress, the vulnerability diagnosis tool can be used to identify the user ID and a password list attack to successfully sign in. After signing in, you can experience unauthorized operations by an intruder, such as tampering with Web contents or setting up a port for a back door.

For both deliverables, the user experiences an intruder experience, and after the experience, consider an educational program in which a group discussion is held as an opposite position (server administrator) on how to prevent intrusion. Under the 2020 plan, it is possible to have students actually use these deliverables and aim for further quality improvement from feedback.

Conclusions and Future works

At KOSEN, in 2019, a faculty development project was launched with the aim of dramatically improving the skills of the faculty members who are leaders in order to sustain and accelerate the development of information security students who are strong in cyber security. There are two main goals, one is the improvement of teachers' skills, and the other is the developing and spreading the excellent teaching materials which is made by the improved skills. The plan is a two-year plan. In 2019, we improved the skills of teaching staff and developed teaching materials. In 2020, lectures will be given and curriculum will be constructed using the developed teaching materials. These skills and feedback will lead to spirals and enhance your plans. The success of this plan will greatly contribute not only to security education but also to examination of new ways of KOSEN education, which mainly focuses on practical education.

In this paper, the effect of security education for teachers in the first year, the evaluation of the methodology, and the confirmation of the deliverables were confirmed. A list of cyber security knowledge and skills required for human resources who will be responsible for cyber security education at KOSEN in the future, and as a result of implementing a training plan with the aim of improving those knowledge, knowledge on all items from before to after implementation・ Skills were improved and the validity of the training content was suggested. Also, in the evaluation of the training plan itself, we showed a good evaluation of the effects of team participation, the validity of theme setting, and the validity of the difficulty level of the theme, and obtained sufficient results to be passed on to the plan for the next year. One issue was the simplification of information sharing within the team. Based on these results, we are currently formulating a training plan that can be improved more accurately.

We also achieved a certain level of success in the development of teaching materials. Completing the cyber range of two scenarios suitable for use in lectures enables a practical deployment plan rich in variations. In the plan for the second year, we can expect to get feedback from students so that they can actually use it, brush up to better teaching materials, and at the same time contribute to improving the skills of faculty members.

Aiming to build a sustainable and effective cybersecurity education methodology suitable for KOSEN students, the results were sufficient for further study, and the plan for the first year was satisfactory.

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INTRODUCTION OF GLOBAL ENGINEER NURTURING PROJECT AND THE EDUCATIONAL EFFECT

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Abstract

National Institute of Technology, Akita college started *Global Engineer Nurturing Project*, which aimed at raising students' ability to communicate in English and enhancing their interests in acting overseas. This paper sees the three programs, which situate at the core of the project, and shows that the introduction of the two programs out of the three results in the improvement of the students' English abilities. *Global Engineer Nurturing Project* consists of the three programs. *English Village* is a 3-days English learning program for the second-grade students, which is supported by Akita International University. This program puts a premium on bringing out their feelings that communicating in English is enjoyable. *Short-term English Training Program at Singapore* is a 9-days program at Singapore. In this program, the third-grade students study how to give a better presentation to the audience in English. It is provided by the teaching staff in Singapore Polytechnic. *Five-months Internship Program* (this program will be started in 2021) gives the students the opportunity to study abroad or participate in overseas internship for 5 months. The content of a research or an internship which is received at an educational institution or a company in overseas is evaluated by our teaching staffs, and then a participant will be qualified as acquiring credits of Graduation Research. After looking at these programs, the paper demonstrates that the two programs which are already implemented improve the students' English abilities and students' interests in going abroad. Rise of their English abilities is verified by comparing the mean score of the TOEIC test, which is taken by fourth-grade students in the past six years; the academic year 2014 through 2019. The data will clearly indicate the dramatic change of the mean scores between the academic year students with whom the programs are provided and those with whom are not. Furthermore, the statistic result on the questionnaire reveals the rise of the number of students who are interested in going overseas.

Keywords: *Global Engineer Nurturing Project, English Village, Short-term English Training Program at Singapore, Five-months Internship Program, TOEIC*

Introduction

The purpose of this project is to meet the current business trend: acceleration of globalization on Japan industry. More and more companies in Japan have moved their factories to other countries. This indicates that Japan's corporations require more engineers who have ability to communicate with the local workers as well as the wide range of expertise and skills as engineers. To serve such needs of Japan industry, our project is constructed.

Organization of this paper is as follows. Section 2 deals with the contents of three pillars on the project: *English Village* program, *Short-term English Training Program at Singapore*, and *Five-months Internship Program*. Section 3 shows the educational effects of the project. This section demonstrates that the two programs which are already conducted improve the students' English abilities and students' interests in going abroad. Rise of their English abilities is verified by comparing the mean scores of the TOEIC test. As for the rise of students' interests in overseas, we will confirm the statistic data from the questionnaire given by the students in section 4. Finally, section 5 consists of the conclusion of this paper and further remarks on the project.

Contents of *Global Engineer Nurturing Project*

National Institute of Technology (KOSEN) is a tertiary college which provides a continuous five-year education program. Graduate students from KOSEN obtain the same skills and knowledges as those who graduate from universities. Akita college introduced *Global Enginner Nurturing Project* into our educational program. The project consists of the three programs: *English Village* program, *Short-term English Training Program at Singapore*, and *Five-months Internship Program*. *English Village* program provides the students with the opportunity to raise their communication skills in English. By *Short-term English Training Program at Singapore*, the students have a chance to go abroad and to learn how to give a better presentation to the audience in English.

As a final stage of the project, *Five-months Internship Program* enriches the students' capacity for adaptation at overseas. Through undergoing these programs, students receive fundamental skills as global engineers. This section describes those programs in detail.

Global Engineer Nurturing Project starts with *English Village* program. It is a 3-days English learning program for the second-grade students. This program owes a lot to the teaching staffs and students at Akita International University (AIU). The undergraduate program at AIU offers all subject matter courses taught in English only. With utilizing the techniques on English education of AIU, the teaching staffs and students in AIU provide our students with English training program. The number of participants on the program is restricted to maximum 40 students every year due to the capacity of the class on AIU. The concept of the English training program is the following; (i) During attending the program, the students in Akita KOSEN are to communicate in English within their English knowledge (Learning new words or new grammar is prohibited), and (ii) This program puts a premium on bringing out their feelings that communicating in English is enjoyable. Table 1 shows a rough description of the activities in the program. Day 1 activities are aimed at evocation of our students' feelings

Table 1: Contents of Activities in English Village

	Contents of Activities
Day 1	Opening ceremony Icebreaking Say it in English Health volleyball
Day 2	Interview with conversation partners Learning how to keep presentation going Preparation for the short presentations
Day 3	Short presentations with Q and A Closing ceremony

that communication in English is enjoyable. The purpose of Day 2 activities is to know what extent they can communicte in English within their English knowledge. Day 3 activities give our students the confidence for communicating in English. As we will see in the next section, *English Village* program reduced the participants' anxious feelings in using English.

As a next stage, our college offers *Short-term English Training Program at Singapore*, in which the third-grade students have a chance to go abroad and to learn how to give a better presentation to the audience in English. The program can be given only for applicants who have Common European Framework of Reference for language (CEFR) B1 level. It was commenced independently in academic year 2014. Afterwards, this program was incorporated into the *Global Engineer Nurturing Project*. The highly interactive course is customized and provided by Singapore Polytechnic. The course covers the following topics in the contexts of communicating for social purposes, and cross-cultural communication: (i) Using conversational English, (ii) Speaking with a foreigner, and (iii) Appreciating cultural diversity. For methodology and approach, this course engages the students through (a) Mini-quizzes and structured games focusing on the use of English, (b) Facilitated role-plays on the use of communication skills among students, (c) Topical speaking and writing tasks during classes, (d) Cross-cultural exchange and presentations, and (e) Trainer's feedback and evaluation on role-plays. During the course, students in Singapore Polytechnic always support our students. Below is Table 2, which represents an example of the itinerary and the contents of the course on the program.

Table 2: An Example of Itinerary on Short-term English Training Program at Singapore

Day 1	Move from Akita to Singapore (flying overnight)
Day 2	Arriving at Singapore Polytechnic Opening ceremony Icebreaking Lecture on presentation Making a manuscript for presentation (Theme 1)
Day 3	Giving a presentation (Theme 1) Conversation training by using games Lecture on Singapore English (Singlish) Lecture on debating Interview on Singapore culture Making a manuscript for presentation (Theme 2)
Day 4	Giving a presentation (Theme 2) Making a manuscript for final presentation Poster presentation on newspaper articles Making a manuscript for presentation (Theme 3) Watching movie
Day 5	Giving a presentation (Theme 3) Poster presentation on watching movie Short excursion: learning local life-styles Making a manuscript for final presentation Making a manuscript for presentation (Theme 4)
Day 6	Giving a presentation (Theme 4) Giving a final presentation Closing ceremony
Day 7	Singapore sightseeing
Day 8	Singapore sightseeing Move from Singapore to Tokyo (flying overnight)
Day 9	Move from Tokyo to Akita

As we will see in the next section, introduction of this program led to the dramatical rise of the mean scores of TOEIC test on National Institute of Technology, Akita college.

As a final phase of the project, our college prepares *Five-months Internship Program*. Note that this program will be started in the academic year 2021, so this paper describes a rough sketch on the program. The program gives the students the opportunity to study abroad or participate in overseas internship for 5 months in order to enrich the students' capacity for adaptation at overseas. Participants of the program will be fifth-grade students (the senior-year students of Akita college). The number of participants on the program is expected to be 16 students every academic year (around one-tenth out of the fifth-grade students). There are three patterns to be considered: (i) To do an academic research at an educational institution in overseas for five-months which concluded the international exchange agreement with our college, (ii) To do an internship at a company in overseas for five-months, or (iii) To do an academic research at an educational institution overseas for three-months and then to do an internship at a company in overseas for two months (the combinational pattern of the above (i) and (ii) cases). The content of a research or an internship is evaluated by our teaching staffs, and then a participant will be qualified as acquiring credits of Graduation Research. In our educational curriculum, almost all the classes for the fifth-grade students will be finished by the first-term period (period from April through August) of the academic year, leaving only the credits for the graduation research. If this program is implemented during the second-term period (period from September to January), the participants can graduate from our college without repeating the same grade.

Table 3: Educational Institutions Concluding the Agreement with Akita College

Country	Educational Institutions
France	IUT 'A' de Lille IUT de Bethune IUT de Lens IUT Calais-Boulogne IUT de Blois IUT du Havre IUT de Valenciennes
Finland	Helsinki Metropolia University of Applied Science Turku University of Applied Science
Vietnum	Central Region College of Technology, Economics, and Water Resources Thuyloi University
Thailand	Thai-Nichi Institute of Technology

Table 3 exhibits educational institutions which have concluded the agreement with Akita College. Our current task is to increase the number of educational institutions overseas which can receive our students as international exchange students, because there seems to be deviation depending on student's research field; many institutions can receive our students in the field of electric and information engineering, whereas we are short of the number of universities who can accept the students in the field of civil engineering or disaster prevention. Furthermore, we have to look for the company located in overseas where we can send our students.

The Educational Effects of *Global Engineer Nurturing Project*

This section focuses on the educational results on *English Village* program (targeting second-grade students) and *Short-term English Training Program at Singapore* (targeting third-grade students).

The educational effects on the *English village* program can be seen from the statistic result on Foreign Language Classroom Anxiety Scale (FLCAS), which is advocated by Horwitz et al. (1986). The FLCAS consists of 33 questions which are scored on a 5-point scale. The questionnaire is implemented twice (*before* and *after* the *English Village* program) by giving the same questions to the participants. This investigation reveals students' change of mind on the anxiety of using English through participaing in the *English Village* program. Figure 1 and Figure 2 reveal the statistic change on Language anxiety level before and after 40 students' attending the program, respectively.

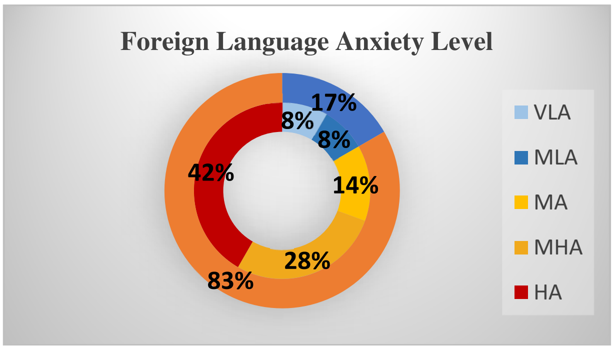

Figure 1:Participants' Language Anxiety Level *before* English Village program

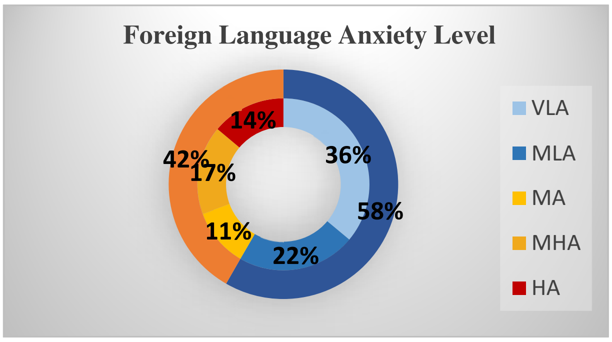

Figure 2:Participants' Language Anxiety Level *after* English Village program

In these graphs, each acronyms described at right side indicate the following meanings; VLA means Very Low Anxiety, MLA is the acronym of Moderately Low Anxiety, MA expresses Moderate Anxiety, MHA stands for Moderately High Anxiety, and finally HA represents High Anxiety. In circles given Figure 1 and 2, inner circles show the students' rate of anxiety by 5 scales ranging from VLA to HA. On the other hand, the outer circles specify the participants' language anxiety scale by 2 levels; the orange-colored part represents the category of relatively high anxious level (MA, MHA, and HA), while MLA and VLA fall into the domain of relatively low anxious levels (the blue-colored part). Comparing the rate of blue-colored part of the outer circle between Figure 1 and Figure 2, which is categorized as low anxious level on using English, we can realize that *English Village* program raises the rate of the students' low anxiety level on communicating in English from 17% to 58%. In contrast to the increase of the rate of students' low anxiety level, the rate of relatively high anxious level drops by half (from 83% to 42%). This result shows that the introduction of *English Village* program gives rise to the educational effect on our students. The result stems from the contents of the program: they are constructed to bring out participants' feelings that communicating in English is enjoyable. As the course went, the participants felt that they could communicate in English within their current English knowledge.

Let us change our attention to the educational effect on *Short-term English Training Program at Singapore*. Although Abe and Daga (2018) stresses the beneficial aspects on students' growth, this article focuses on the improvement of students' English abilities. The evaluation on this program is provided by TOEIC score. In our school, taking a TOEIC test is a mandatory for all the fourth-grade students.

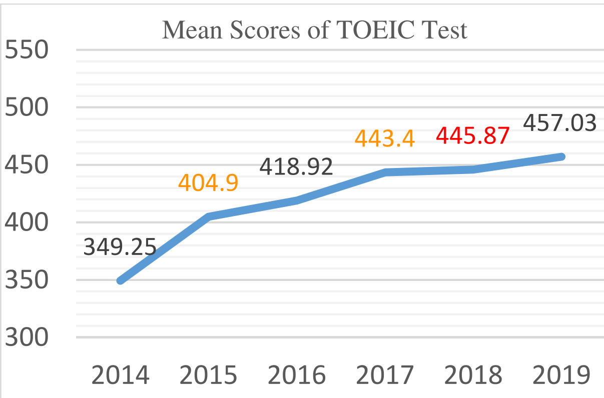

Figure 3: Mean Scores of TOEIC Test by All Fourth-grade Students

In Figure 3, the vertical axis indicates the points of TOEIC test; whereas the horizontal axis stands for the academic year. The value of the Figure 3 represents the mean scores of TOEIC test taken by all fourth-grade students in six successive academic years. Notice that we can draw a boundary line between the academic year 2014 and 2015. Before the academic year 2014, there had been no academic year that exceeded the value of the mean score 350. On the other hand, the value of mean score of TOEIC test has been not less than 400 points since the academic year 2015. Furthermore, the value of TOEIC score in the academic year 2019 reaches approximately 457 points, which exceeds the mean score of all Japan's university students in the academic year 2019: 454 points. (The mean score of all Japan's KOSEN students is 361 points in the academic year 2019.) What happens between *before* the academic year 2014 and *after* 2015? The answer is that *Short-term English Training Program at Singapore* has been introduced for third-grade students since the academic year 2014. The result of the program should be realized as the mean score of TOEIC test from the academic year 2015 onwards in Figure 3. For instance, the educational effect on *Short-term English Training Program at Singapore* for the third-grade students in the academic year 2017 can be evaluated in the mean score of the TOEIC test for the fourth-grade students in the academic year 2018. If this is the case, Figure 3 clearly shows that the introduction of *Short-term English Training Program at Singapore* has brought a big impact on raising the ability to communicate in English for the students. Some readers may wonder why such an effect ensues even if only the subset of all students participate in the program. The next section will be concerned with this matter.

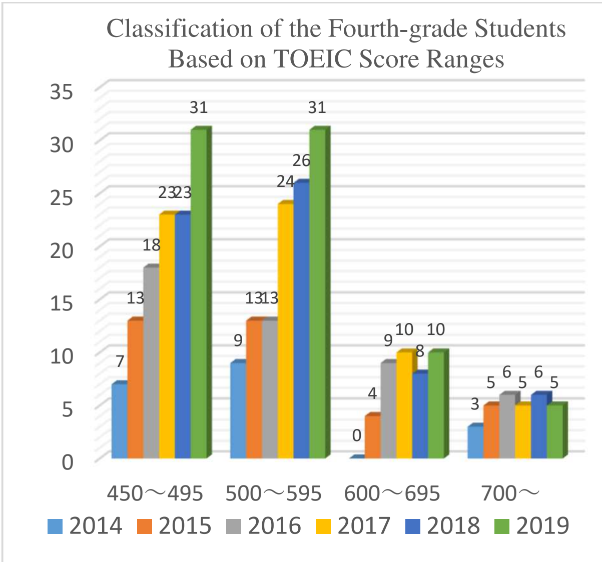

Figure 4: Classification of the Fourth-grade Students Based on TOEIC Score Ranges

To examine the result of mean scores of TOEIC test in detail, let us see Figure 4, which gives the classification of the students on the basis of TOEIC score ranges. Figure 4 illustrates the number of the students ranging over the score 450 points. The vertical axis is the number of the students, whereas the horizontal axis stands for the four types of score ranges of TOEIC. Every score range represents the number of the student belonging to the range from the academic year 2014 to 2019. According to the bar graph, the number of students have increased who get the score ranging from 450 points through 695 points, although those who belong to the group over 700 points seem to have remained intact for six years.

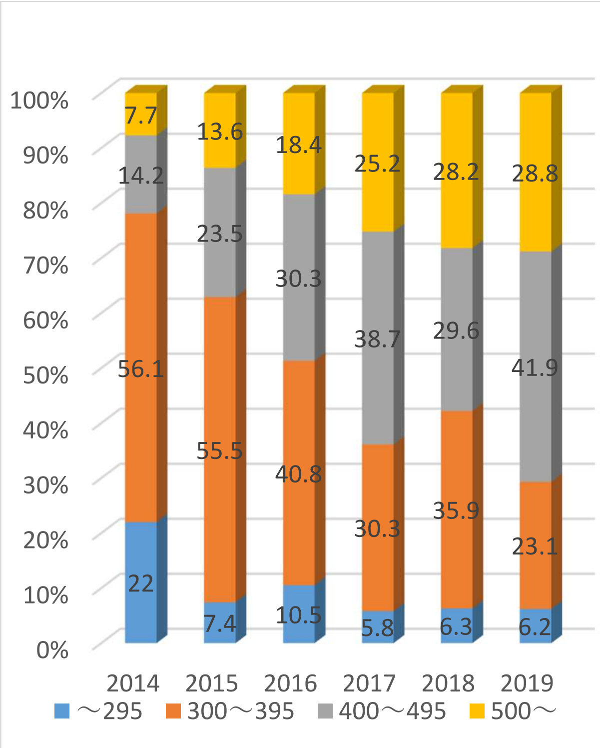

Figure 5: Percentage of the Students in the Group of Each TOEIC Score Ranges

Figure 5 indicates the percentage of the students belonging to each TOEIC score ranges from academic year 2014 through 2019. Vertical axis and horizontal axis describe the percentage of the students amang fourth-grade students and academic years, respectively. TOEIC score ranges are classified by four categories; under 300, 300~395, 400~495, and over 500. As an example, 40.8 percent of the students in 2016 belong to the score group 300~395. The figure shows that the rate of the students belonging to over 400 has increased. Notice that the increase of the rate of the students over 400 points coincides with the rise of the mean scores of TOEIC test in Figure 3. In short, the key to raising the mean score of TOEIC is to increase the number of the students who get 400s on TOEIC scores. Combination of Figure 4 and 5 suggests that, although the Singapore program succeeds in raising the number of the students who ranges from 400 to 595 on TOEIC score, another program or method should be added in order to increase those who get over 600 points.

Statistic Results on Questionnaire

This section mainly focuses on the statistic results on questionnaire given by students. The results will give answers to the following two questions: (1) Does the rise of students' interests in overseas ensue by the introduction of *English village* program?, and (2) why does *Short-term English Training Program at Singapore* cause the rise of mean score of TOEIC test in all fourth-grade students despite of some students' participating in the program?

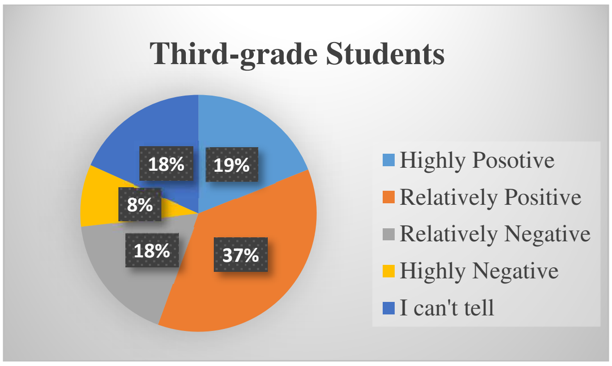

Figure 6: The Statistic Result on the Question *Are You Interested in Going Overseas?* for Third-grade Students

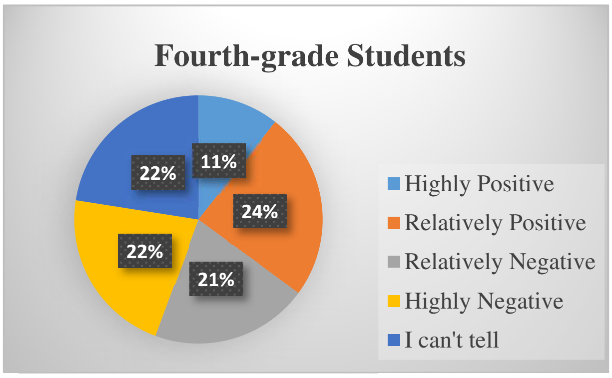

Figure 7: The Statistic Result on the Question *Are You Interested in Going Overseas?* for Fourth-grade Students

Let us look at Figure 6 and 7, which give a key to the answer of the first question. The survey respondents are all the third-grade students (who received the chance of *English village* program) and all the fourth-grade students (to whom the opportunity of the program is not offered). Both figures show the result of the answer to the question *Are you interested in going overseas?* The scale of the result is scored by 5 point: highly positive, relatively positive, relatively negative, highly negative, and I can't tell. According to those figures, the rate of highly or relatively positive answers in third-grade students is higher by 21% than those of fourth-grade students. The result implies that *English village* program contributes to the rise of the persentage of the students who have positive impressions in going overseas.

We now have to tackle with answering the second question. From logical perspective, one may think that the educational effect on the Sigapore program is limited because only some of the students (not all of them) join the program, but, as far as we saw in Figure 5, the idea is not correct. If so, what brings the educational ripple effect of Singapore program to the entire fourth-grade students? The clue of the answer can be given by considering the result of the survey shown in Figure 8 and 9. Figure 8 shows the result on the question *Who do you ask about TOEIC?* for all fourth-grade students.

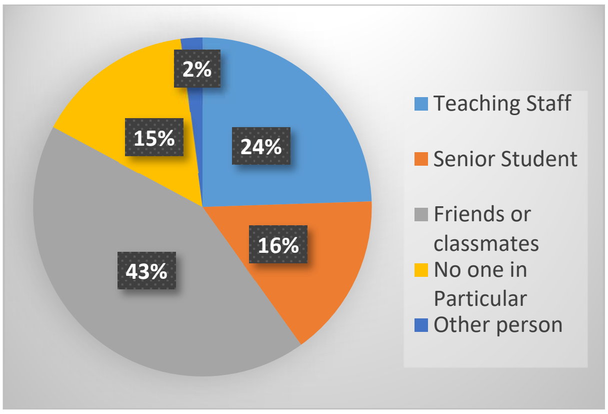

Figure 8: The Statistic Result on the Question *Who Do You Ask about TOEIC?*

The staggering statistics are provided: approximately 60% of the students ask their senior students, friends, or classmates; whereas those who ask teaching staffs occupy only a quarter of all fourth-grade students. The data indicate that students are more likely to ask advice from students who have close relationship to them than teaching staffs. Furthermore, the lower the TOEIC score is, the greater the tendency is.

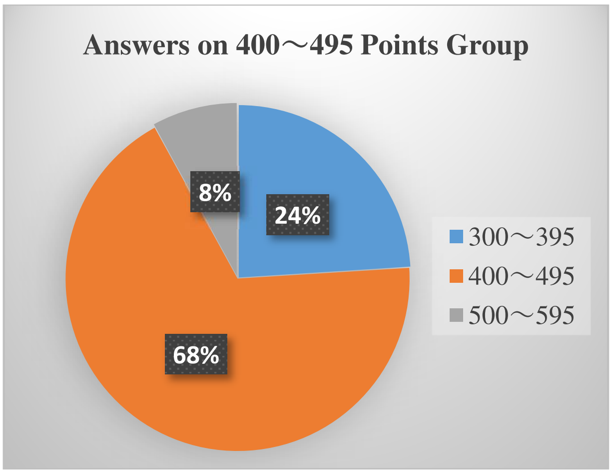

Figure 9: The Statistic Result on the Question *What score do you say when you are asked how many points one should get on TOEIC?*

Next is concerned with Figure 9, which represents the answers on the question *What score do you say when you are asked how many points one should get on TOEIC?* for the 400~495 point students. The figure reveals that students' answering scores tend to be the same as those which they get. The same is true for the other scoring groups. For instance, the majority of 300~395 scoring group answer the value of 300~395 range. The fact indicates that when the number of the students who owns more than 400 points on TOEIC increases, many people take it for granted that a student gets at least 400 point on TOEIC test. If so, according to the Figure 8 and 9, when a student getting 350 point consults his friends on TOEIC score, they will advise him to get at least 400 point. Under this circumstance, students with TOEIC scores under 400 feel isolated and begin to strive in order to be the same as the major students. This is exactly what has happened in our students. Even if only some students had participated in Singapore program, by their producing the rise of the number of the students who got more than 400 on TOEIC and creating the atmosphere that getting at least 400 point was normal, the remainder were forced to make an effort to avoid isolation, which led to the increase of the mean score of TOEIC test in entire fourth-grade students. In other words, the introduction of the program for only a subset of students can spread its educational effect into the entire school-year students.

Conclusions

This paper described the details of the contents on *Global Engineer Nurturing Project* and the educational effects. *English village* program induced to the participants the pleasure of communicating in English and the interest in going overseas. *Short-term English Training Program at Singapore* played an important role for raising the mean scores of TOEIC test on fourth-grade students. Furthermore, we saw that the introduction of the program for only a subset of students could give rise to its educational ripple effect into the entire school-year students. The key to causing the effect was to increase the number of the students with high score. As for *Five-months Internship Program*, we touched only a rough design because this program has not been started yet. We hope that this program will make a significant contribution to fostering students who can work actively in overseas.

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LINE TRACE CAR EXPERIMENT

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Abstract

It's a challenge to foster computer science engineers knowing control techniques for developments of the self-driving or self-moving robots with AI. We introduce a new educational tool and evaluate its effectiveness in helping the students understand the statistical approach of Bayesian inference. A line tracer is a popular educational material for programming. Anyone can make it by using a car equipped with wheels that can spin independently on both sides, a photo reflector that can sense a line, and a micro-computer like an Arduino board. However, when one tries to make it circle a course as fast as possible, it becomes hard to satisfy smoothness and accuracy. It's difficult, especially in the complex course. The development of the line trace car makes a chance for the students to take an interest in controlling on top of programming. This paper introduces an algorithm for the line trace car with the particle filter. It can detect the line with 5 photo reflectors lined in the direction transverse to the car. They allow the car to estimate three states, offset and angle to the line and curvature of the line. The car can run smoothly fitting a curve if the estimates are right. The movement of the car takes the role of inference of the states as well as control. Students can realize the effectiveness of Bayes' theorem on which the particle filter algorithm is based. They can improve the accuracy of estimation by running the car and discussing it in a team. These experiences should motivate students to study automatic control systems. The effectiveness of this educational material is going to be assessed based on the questionnaire after introducing this to an Electronic Information Communication Experiment class for 5th-year students of the Department of Computer Science and Electronic Engineering, National Institute of Technology, Tokuyama College. The first question is "Did you get interested in controlling objects?" The second is "Did you understand the Bayes' theorem and realize the effectiveness of the particle filter algorithm?" The final one is "What objects do you want to control in the future?"

Keywords: *particle filter, line trace car, Bayes' theorem, student experiment, Kalman filter, control techniques*

Introduction

Yasumura et al. (2019) started to develop the line trace car to be adapted to the student experiment for learning automatic control. It would be great if we could apply the particle filter and the Kalman filter to familiar line trace cars and learn them experientially. Moreover, once you understand the Bayesian theorem, which is the basis of these controls, you will be more interested in control. In this paper, we first introduce the story to understand the Bayesian theorem, the development to the particle filter, the implementation to the line trace car, and the application of the Kalman filter.

Bayes' Theorem

In one TV show, a moderator and a pair of parent and child stand in front of three doors on a stage. Behind one of the doors, there is a car as a prize. The moderator instructs the parent and child to choose one door and stand in front of it. When the parent and child do so, the moderator opens the other one door and shows a goat. And he said, "Now you can change to another door." What would you do if you were the parent and child?

Table 1. The joint distribution of the door's correctness and being opened when the parent and child chose the C door.

	A'	B'	C'	Correct
A	0	1/3	0	1/3
B	1/3	0	0	1/3
C	1/6	1/6	0	1/3
Opened	1/2	1/2	0	1

At first, the probability of any door's correctness is 1/3. If the parent and child chose the C door, the probability of moderator's opening the door is 1/2 for both A and B. That can be derived from the simultaneous and peripheral probabilities of Table 1. Since the moderator knows the truth, his action depends on the state and the choice of the parent and child.

If the moderator opened the door A (= A'), the probabilities of the correctness of B and C are

$$\mathrm{P(B|A')} = \frac{P(B \cap A')}{P(A')} = \frac{P(A'|B)P(B))}{P(A')} = \frac{1}{3} \div \frac{1}{2}$$
$$= \frac{2}{3} \qquad \text{(B is correct)}$$
$$\mathrm{P(C|A')} = \frac{P(C \cap A')}{P(A')} = \frac{P(A'|C)P(C)}{P(A')} = \frac{1}{6} \div \frac{1}{2}$$
$$= \frac{1}{3} \qquad \text{(C is correct)}$$

B’s probability becomes 2/3 and C’s becomes 1/3, so it is better to change to the B door rather than C.

Also, if the moderator opens the door B (= B ')

$$\mathrm{P(A|B')} = \frac{P(A \cap B')}{P(B')} = \frac{P(B'|A)P(A)}{P(B')} = \frac{1}{3} \div \frac{1}{2}$$
$$= \frac{2}{3} \qquad \text{(A is correct)}$$

$$\mathrm{P(C|B')} = \frac{P(C \cap B')}{P(B')} = \frac{P(B'|C)P(C)}{P(B')} = \frac{1}{6} \div \frac{1}{2}$$
$$= \frac{1}{3} \qquad \text{(C is correct)}$$

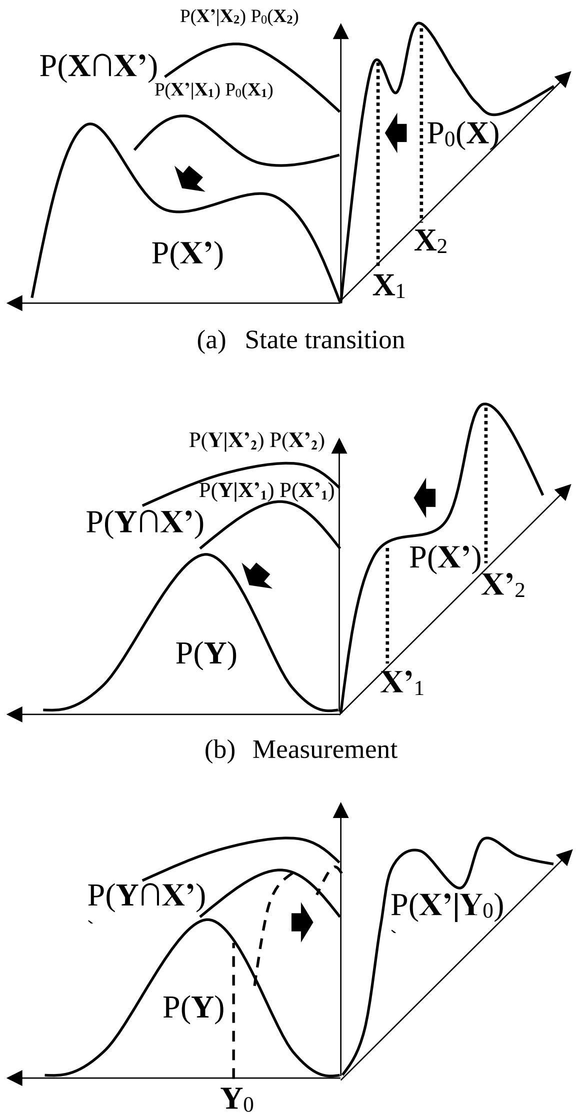
A’s probability is 2/3 and C’s is 1/3, and in this case, it is better to change to the A door.

Particle Filter

Let's return to the line trace car. The particle filter is a method of expressing the probability for a state to be estimated by the number of particles and controlling appropriately while estimating the state. Particles represent a unit of possibility, and it can be said that the more particles exist, the higher the probability of the state is. Particles can change their state depending on the change of conditions and the lapse of time. It is also possible to give a probability distribution by transitioning from the state to the measured value. For example, if you can run high jumps and keep a good run, it will be easier to cross the bar at the end. In this way, when the joint probability distribution of the state and the observed value after a certain time is obtained, the state probability can be updated based on the measured information. Bayes' theorem is used here. These steps are depicted in Figure 1.

In the problem of doors, the state to be estimated is “the presence of a prize”, and there are three states A, B, and C. Corresponding to the control is "the action of the parent and child choosing the door and standing in front of it". The information that was observed was a "door opened by the moderator," and there were three types: A', B', and C'.

What exactly are the states, controls, and observations in the line trace car? The "state" is the deviation between the line and the vehicle body, the angle, and the curvature of the curve. There are three types of "control": straight ahead, left spin, and right spin. And "observation" is the output of the five photo reflectors.



(a) State transition

(b) Measurement

(c) Inference

Figure 1. Three phases in a time step of the particle filter

Line Trace Car

First of all, we need to know the structure of the line trace car. Using the coordinates shown in Figure 2, the positions of the five sensors are read and stored in the arrays like sensor_x0 [0-4] and sensor_y0 [0-4]. A center of rotation is determined by measuring the radius and length.

The movement performances of the line trace car are tested by following experiments with SPEED set to 120.

Program the car to run for 1 second and stop, and measure the distance. Program the car to spin for 1 second and stop, and measure the angle. The results can be used as velocity and angular velocity in the program, but they should be revised more properly viewing the performance. The results are shown in Table 2.

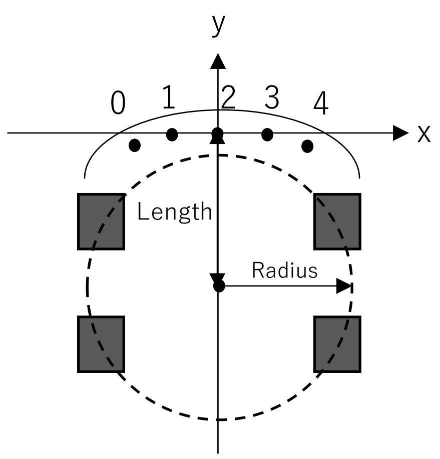


Figure 2. Arrangements of photosensors and dimensions of the line trace car

Table 2. Arrangements of photosensors and dimensions and specifications of the line trace car

Number	0	1	2	3	4
x [cm]	-4.8	-2.1	0	2.1	4.8
y [cm]	-0.4	0	0	0	-0.4
Length [cm]		11	Radius [cm]		9
Velocity [cm/s]		74	Angular Velocity [rad/s]		2.4

Ideally, plenty number of particles should be used to model the transition of the probability distribution, but the microcomputer cannot process it in real-time. Therefore, the possible states of particles are limited as shown in Table 3. As a result, the possible number of state transitions is reduced to 3,087, which allows us to calculate and memorize all of them before the car starts.

It is necessary to connect the state after transition and the observed sensor state. Figure 3 shows the case where the offset, the angle, and the curvature are all positive.

Prediction of state transition can be explained using Figure 4. The figure shows the change when the curvature is negative and the machine selects left spin. It rotates about T about the center of rotation.

It is necessary to decide the control according to the last estimated state. Control depends only on offset and angle, not on curvature as shown in Table 4.

Table 3. States of the line and the line trace car

Number	0	1	2	3	4	5	6
Curvature [cm]	-64	-20	-3	0(∞)	3	20	64
Offset [cm]	-10	-4	-2	0	2	4	10
Angle [degree]	-45	-30	-15	0	15	30	-45

Table 4. The Controls of the line trace car

Offset	Angle	Control
D > 0	A < 0	Left Spin
D < 0	A > 0	Right Spin
Otherwise		Straight

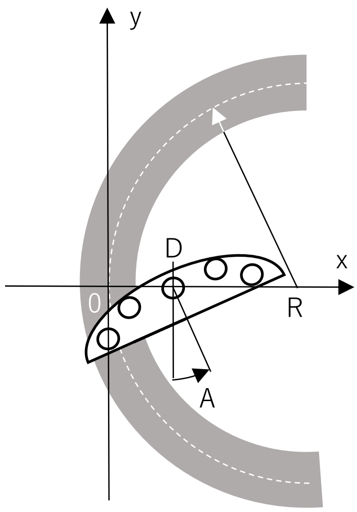


Figure 3. States of the line and the line trace car

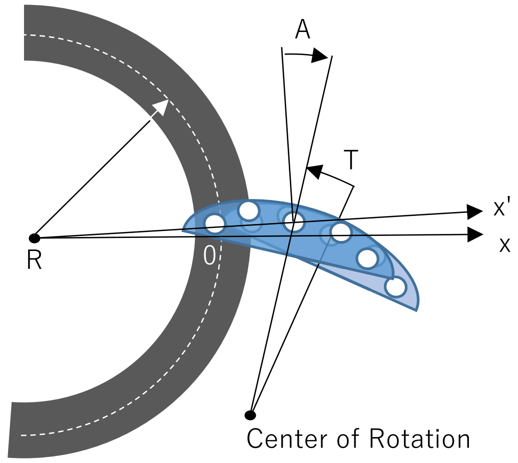


Figure 4. State transition of the line trace car

The values of the five sensors are matched between the predicted value and the measured value. Particles that do not match at all are discarded. The particles need to be well dispersed so that all the particles do not disappear. For example, the speed can be changed to 0 time, 1 time, and 2 times, and the weights are set to 0.25, 0.4, and 0.35, respectively. Also, the probabilities concerning the curvature are uniformly distributed. However, concerning the original curvature, the weight was set to be twice that of other curvatures.

The flow chart of the line trace car is shown in Figure 5. The line trace car was developed based on OSOYOO Robot Car Starter Kit. The controller board compatible with UNO R3 was replaced with the Arduino Mega R3 board because it requires 6,545 bytes for global variables.

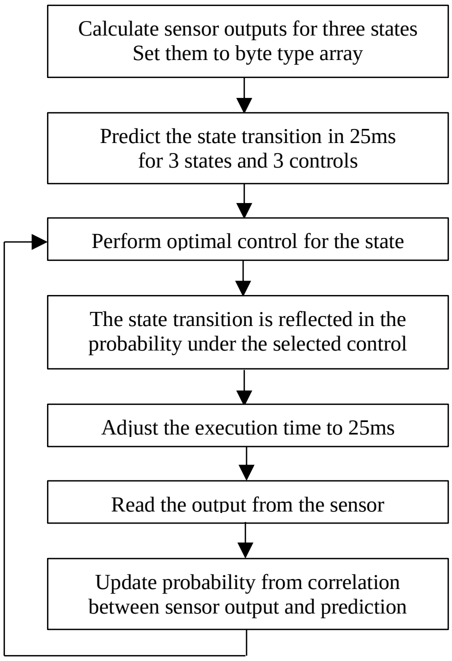


Figure 5. Flow chart of the particle filter

Kalman Filter

The offset D and the angle A of the vehicle body to the line are estimated. They are depicted in Figure 6. The bivariate normal distribution is the joint probability density function of the probability vector **x** = (d, a)^t. The bivariate normal distribution is uniquely determined by the following mean vector and variance-covariance matrix.

Probability vector:

$$\mathbf{x} = \begin{pmatrix} d \\ a \end{pmatrix}$$

Mean vector:

$$\boldsymbol{\mu} = \begin{pmatrix} \bar{d} \\ \bar{a} \end{pmatrix}$$

Variance-covariance matrix:

$$\Sigma = \begin{pmatrix} \overline{(d-\bar{d})^2} & \overline{(d-\bar{d})(a-\bar{a})} \\ \overline{(d-\bar{d})(a-\bar{a})} & \overline{(a-\bar{a})^2} \end{pmatrix}$$

Bivariate normal distribution:

$$\mathrm{X} \sim N(\boldsymbol{\mu}, \Sigma)$$

Nomura (2016) has described the linear transformation of multivariate normal distributions and their conditional probability distributions.

Ristic et al. (2004) show the procedure of Bayesian estimation by Kalman filter.

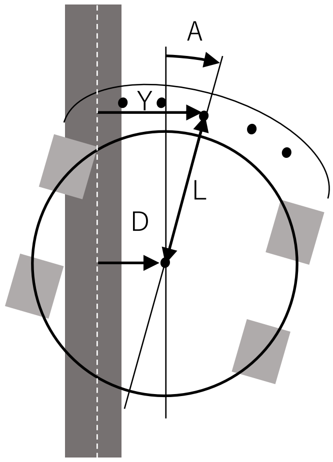


Figure 6. States and measurements of the line trace car

Linear transformation of the probability vector (F: 2 × 2 matrix):

$$\mathbf{x}' = \mathrm{F}\mathbf{x} + \mathbf{b}$$

Mean vector:

$$\boldsymbol{\mu}' = \mathrm{F}\boldsymbol{\mu} + \mathbf{b}$$

Variance-covariance matrix:

$$\Sigma' = \mathrm{F}\Sigma\mathrm{F}^t$$

Bivariate normal distribution transformed:

$$\mathrm{X}' \sim N(\boldsymbol{\mu}', \Sigma') = N(\mathrm{F}\boldsymbol{\mu} + \mathbf{b}, \mathrm{F}\Sigma\mathrm{F}^t)$$

Linear transformation of probability vector representing state transition:

(Left Spin)

$$\mathrm{F} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$$
$$\mathbf{b} = \begin{pmatrix} 0 \\ \omega\Delta t \end{pmatrix}$$

(Right Spin)

$$\mathrm{F} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$$
$$\mathbf{b} = \begin{pmatrix} 0 \\ -\omega\Delta t \end{pmatrix}$$

(Straight)

$$\mathrm{F} = \begin{pmatrix} 1 & -v\Delta t \\ 0 & 1 \end{pmatrix}$$
$$\mathbf{b} = \begin{pmatrix} 0 \\ 0 \end{pmatrix}$$

Linear transformation of the probability vector (H: 1 × 2 matrix):

$$\mathrm{y} = \mathrm{H}\mathbf{x}' + \mathrm{b}$$

Mean value:

$$\mathrm{E(y)} = \mathrm{H}\boldsymbol{\mu}' + \mathrm{b}$$

Variance:

$$\mathrm{V(y)} = \mathrm{H\Sigma' H}^t$$

A normal distribution (observed value):

$$\mathrm{Y} \sim N(\mathrm{H}\mathbf{x}' + \mathrm{b}, \mathrm{H\Sigma' H}^t)$$

Linear transformation of a probability vector representing a measurement:

$$\mathrm{H} = (1 \quad -L)$$

$$\mathrm{b} = 0$$

The conditional distribution of **x**' under the given measured value y_0 also follows a bivariate normal distribution, and its mean and variance are given by the following equation. This becomes **x** in the next step.

$$\mathrm{E}(\mathbf{x}'|\mathrm{y}_0) = \boldsymbol{\mu}' + \frac{\boldsymbol{\Sigma}'\mathrm{H}^t}{\mathrm{V(y)}}(\mathrm{y}_0 - \mathrm{E(y)})$$

$$\mathrm{V}(\mathbf{x}'|\mathrm{y}_0) = \boldsymbol{\Sigma}' - \frac{(\boldsymbol{\Sigma}'\mathrm{H}^t)(\boldsymbol{\Sigma}'\mathrm{H}^t)^t}{\mathrm{V(y)}}$$

Bivariate normal distribution:

$$\mathrm{X} \sim N\big(\mathrm{E}(\mathbf{x}'|\mathrm{y}_0), \mathrm{V}(\mathbf{x}'|\mathrm{y}_0)\big)$$

As with the particle filters, it is necessary to avoid that all state probabilities disappear as a result of observation. Therefore, noise is added to the linear transformation for state transition as follows.

$$\boldsymbol{\Sigma}' = \mathrm{F}\boldsymbol{\Sigma}\mathrm{F}^t + \boldsymbol{Q}$$

$$\boldsymbol{Q} = \begin{pmatrix} Offset & 0 \\ 0 & Angle \end{pmatrix}$$

The curvature is not included in the state vector, but the error due to it is taken in this noise.

The control is the same as that of the particle filter shown in Table 4. The only difference is the definition of the offset.

The flow chart of the line trace car is shown in Figure 7. Since all probability distributions are handled as normal distributions, only 314 bytes are needed as global variables.

Experiment

The test course is shown in Figure 8. It has 1,682 mm hight and 2,378 mm width. The thickness of the line is 50 mm. Both particle and Kalman filters have been tried.

First, the particle filter was tested for clockwise and counterclockwise directions. The results are shown in Table 5. For each corner of the course, the number of successes and failures is shown in each direction. Most of the failures were reverse runs. Only the clockwise turn at the 'f' corner was out of the course.

Next, the Kalman Filter was tested. The results are shown in Table 6. All failures were out of the course. It can't follow the line with a continuous reverse curve. The noise values of *Offset* and *Angle* were set to 3 and 10, respectively. These parameters should be optimized.

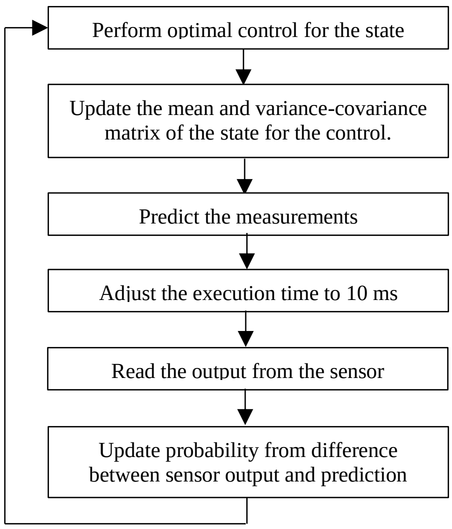


Figure 7. Flow chart of the Kalman Filter

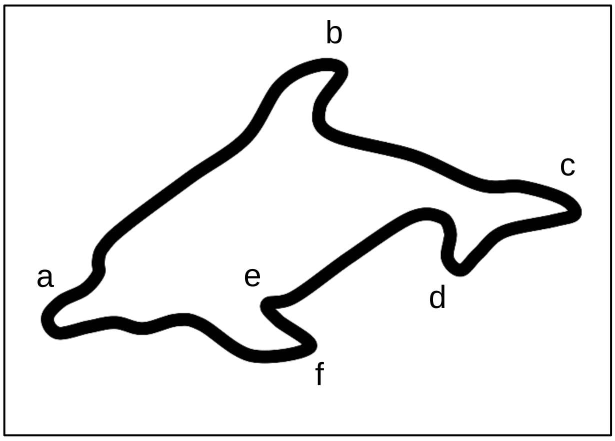


Figure 8. Test course

Table 5. Test results for the particle filter

CORNERS	a	b	c	D	e	f
CW Success	9	9	10	8	7	9
Failure	1	1	0	2	3	1
CCW Success	7	7	7	8	8	9
Failure	3	3	3	2	2	1

Table 6. Test results for Kalman Filter

CORNERS		a	b	c	d	e	F
CW	Success	10	8	10	3	0	0
	Failure	0	2	0	7	10	1
CCW	Success	0	0	0	0	5	7
	Failure	10	10	10	10	1	3

Discussion

For the Kalman filter car, the curvature should be incorporated in the state to better the performance.

For the Particle filters car, weighting on velocity has a large effect on results. Therefore the way of optimization should be studied. The array related to the state is insufficient. Static data need to be written to ROM.

COVID-2020 keeps us from conducting the student experiment. We are currently studying to be able to conduct experiments online.

The speed of the left and right motors can be changed freely. However, the wheels are always parallel to the axis, they cannot bend gently. We should consider a mechanism that gives the car body flexibility.

Shortcuts and protrusions are not properly evaluated. We should study the evaluation method.

Conclusions

Teaching material has been proposed for learning estimating states from control and measurement based on Bayes' theorem. It explains that the way of expressing the probability distribution is the only difference between the particle filter and the Kalman filter. The ideas were verified by experiments on the line trace car. Challenges on performance and evaluation methods have been found. We are going to report on the online implementation method and the evaluation by students in the next article.

Acknowledgments

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EVALUATION OF EDUCATIONAL CONTENT ON CYBERSECURITY AND STUDENT'S SKILL IMPROVEMENT BY THE SKILL CHECK

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Abstract

This paper reports the results of the evaluation of the student's skill improvement and the effectiveness of workshops by the skill check performed educational content on cybersecurity. The K-SEC (KOSEN Security Education Community), which develops educational resources for students on cybersecurity, is an organization of the National Institute of Technology (KOSEN). One of the main activities of the K-SEC is to hold workshops with educational content on cybersecurity for students that K-SEC gives lectures and exercises on security for mainly one or two days. In fiscal 2018, a questionnaire has been performed on the level of difficulty and satisfaction for participants to measure the effectiveness of educational content. The result showed that educational content was beneficial for the participants. In fiscal 2019, a skill check was conducted to measure the effects on the skills improvement of the participants. K-SEC members extract related cybersecurity skills based on educational content. We referred to the "IT Skill Standards" published by IPA (Information Processing Promotion Agency, an organization in Japan in the information field). A questionnaire form in five-grade evaluation, which is based on Bloom's Taxonomy, was prepared from the extracted skills. Participants answered the questionnaire form before and after the workshop. K-SEC members aggregate the results and measure the change before and after the workshop for each skill. The aggregate results show two points. The first is how effective the educational content was in improving participants' skill levels. The second is that the educational content was effective for beginners or advanced participants. The skill checks have been performed at workshops held in K-SEC from June 2019 to January 2020. The results show the average skill level of the target skills improved after workshops, and the educational content is effective in improving participant's skills. This paper reports on the details and the results of the skill checks performed at each workshop and discuss the effectiveness of the skill checks with educational content at the workshops.

Keywords: *K-SEC, KOSEN, skill check, educational content, cybersecurity*

Introduction

It is now commonplace for people to have at least one personal computer, smartphone, or other information terminals to connect to the internet at any time or place. In the industry, the digitalization of business progresses, and the national government promotes policies such as Society 5.0 promoted by the Cabinet Office, and the role of information technology in the society becomes important. On the other hand, the number of cyber-attacks has been increasing due to the development of information technology. To implement countermeasures against cyber-attacks, there is an urgent need for companies to secure human resources with security technology. However, according to the data released by the Ministry of Internal Affairs and Communications, it is estimated that there is a shortage of about 200,000 security personnel in the entire industry. In light of these social circumstances, the National Institute of Technology has been working on the KOSEN Security Education Community(K-SEC) project. This project aims to educate all students on all national institute of technology and to make all graduates play an active role in the industry as security personnel. As a part of K-SEC activities, we hold cybersecurity education workshops. Workshops were held for one or two days with students from all over the country who were interested in security. Besides, we measured whether the students' skills were improved through a questionnaire-style skill check before and after the workshop. By confirming the results of the skill check, we verified whether the workshop was effective in improving students' skills. This paper reports the results of the skills checks in workshops held between June 2019 and January 2020.

Overview of the skills check

The questionnaire for the skills check was carried out as follows.

1. Prepare the skill map created by K-SEC in 2018. This is based on the "IT Skills Standard" published by Information Processing Agency (IPA).
2. After confirming the content of the workshop, pick up the relevant skills and correlate them with the skill map.
3. Generalize the expression of the skill. For example, express it as a general term rather than a specific product name.
4. The level of each skill is expressed as five levels (minimum 1, maximum 5) and is set as a questionnaire.

Participants were asked to fill out the questionnaire before and after the workshop.

Designing a skills check

The level of skill was based on Bloom's Taxonomy. The items related to technology and those related to methodology would be different when expressing skill levels. Therefore, although the points to be expressed on a scale of 1 to 5 and the required level are the same, the appropriate one is set for each expression. The technology is expressed in five levels: "1: unknown", "2: know", "3: can operate and set up basic operations", "4: can build, operate and utilize", and "5: can deal with troubles". The methodology was expressed in five levels: "1: unknown", "2: know (can understand the situation)", "3: can implement the proposed solution", "4: can analyze the event", and "5: can propose and solve the appropriate solution". Because of this design, the results obtained by the skill check questionnaire are five levels of numerical values for level in each skill. Therefore, by quantitatively comparing the improvements in the mean values of the skills of all participants before and after the workshop, we confirmed the effectiveness of the workshop in improving each skill.

The results of the skills check and the effectiveness of workshops

We compared the mean value of the skill check of all the participants before and after the workshop to confirm the effect of the workshop.

CTF Beginners for KOSEN (June 29, 2019, at Kisarazu College)

CTF Beginners for KOSEN is a workshop for students who are the beginner to CTF (Capture the Flag). At the cybersecurity competitions, CTF is often used as a subject. For this reason, the skills required for the general-purpose were examined and summarized into 14 items, referring not only to this workshop but also to past problems.

#1. OS (Windows, Unix, etc.)
#2. Server
#3. Programming languages (JavaScript, CGI, etc.)
#4. Tools (remote control, packet capture, etc.)
#5. Management and monitoring of the log
#6. Layer 1 to 4 (packet, pcap, wired connection, wireless connection, etc.) of OSI reference model
#7. Layer 5 to 7 (HTTP, HTTPS, FTP, Cookie, Port, etc.) of OSI reference model
#8. Encryption technology (RSA, public key cryptography, etc.)
#9. Digitalization of information (coding theory, etc.)
#10. Knowledge of known web vulnerabilities (XSS, etc.)
#11. Knowledge of known client-side vulnerabilities (Exploit, binary, etc.)
#12. Security literacy (social hack, etc.)
#13. File format (Office, PDF, image format, etc.)
#14. Standard of input/output device (USB packet, etc.)

Table 1 shows the results and differences in the mean scores of the skill checks conducted before and after the workshop for the twenty-five participants. The amount of improvement in some skills is negative. However, since it is unlikely that skill level was reduced by the workshop, these skills were not directly related to the content of the workshop. The content of this workshop is related to "Binary", "Web" and "Crypto". Therefore, the improvement of level in the related skill items #8, #10, and #11 shows that this workshop was beneficial for the students' skill improvement.

Table 1. Results of skill check in CTF Beginners for KOSEN（Number of participants: 25）

#	Before workshop (Mean value)	After workshop (Mean value)	Difference
1	2.88	2.84	-0.04
2	2.24	2.16	-0.08
3	2.60	2.56	-0.04
4	1.76	2.08	0.32
5	1.64	2.00	0.36
6	1.80	1.96	0.16
7	1.84	2.08	0.24
8	1.96	2.36	0.40
9	1.64	1.96	0.32
10	1.56	2.36	0.80
11	1.24	2.28	1.04
12	1.80	2.20	0.40
13	2.48	2.48	0.00

Log analysis and SOC exercise (August 9, 2019, at Ishikawa College)

The log analysis and SOC exercise is the workshop to investigate the causes and effects of incidents by analyzing the log data output to the server. For this workshop, we used the teaching materials provided by K-

SEC, so we examined the skill items based on the content and summarized them into 9 items.

#1. UnixOS
#2. Network equipment and configuration
#3. Firewall
#4. Authentication technologies such as Active Directory (AD)
#5. Management and monitoring of log (proxy, AD, terminal)
#6. Security products and services such as SIEM
#7. Cyber-attack techniques
#8. Security measures of the server
#9. What to do when a security incident occurs

Table 2 shows the results and differences in the mean scores of the skill checks conducted before and after the workshop for the twelve participants. The content of this workshop is primarily related to #5 and #6, the improvement of these skills was remarkable, and it can be said that the workshop sufficiently achieved its purpose. There was no change in the skill #3, which was omitted from the workshop, and this was also reflected in the results.

Table 2. Results of skill check in log analysis and SOC exercise（Number of participants: 12）

#	Before workshop (Mean value)	After workshop (Mean value)	Difference
1	2.58	2.92	0.34
2	2.25	2.50	0.25
3	2.33	2.33	0.00
4	1.67	2.25	0.58
5	1.92	3.17	1.25
6	1.50	2.75	1.25
7	1.92	2.33	0.41
8	1.92	2.33	0.41
9	1.75	2.25	0.50

K-SEC security winter school (December 23 and 24, 2019 at Ishikawa College)

In K-SEC security winter school, two courses, "information security course" for information students and "machine control security course" for mechanical students, were held in parallel. In the information security course, we used the same teaching material as "log analysis and SOC exercise" which was held in August 2019. Therefore, the questionnaire of the skill check is the same.

#1. UnixOS
#2. Network equipment and configuration
#3. Firewall
#4. Authentication technologies such as Active Directory (AD)
#5. Management and monitoring of log (proxy, AD, terminal)
#6. Security products and services such as SIEM
#7. Cyber-attack techniques
#8. Security measures of the server
#9. What to do when a security incident occurs

Table 3 shows the results and differences in the mean scores of the skill checks conducted before and after the workshop for the eighteen participants of the information security course before and after the workshop. The trend of skill changes is similar to the results of log analysis and SOC exercise, and it can be said that the workshop was effective. Besides, the effectiveness of the use of teaching materials to improve skills should be discussed.

Table 3. Results of skill check in K-SEC security winter school (log analysis and SIEM exercise, Number of participants: 18)

#	Before workshop (Mean value)	After workshop (Mean value)	Difference
1	2.72	2.94	0.22
2	2.33	2.44	0.11
3	2.33	2.50	0.17
4	1.39	2.11	0.72
5	1.83	2.94	1.11
6	1.28	2.67	1.39
7	1.94	2.78	0.84
8	1.78	2.78	1.00
9	1.56	2.83	1.27

In the machine control security course, we held a workshop to learn about control security through exercises and lectures using PLC (Programmable Logic Controller). We confirmed the content with the teacher who asked us to be the lecturer in advance and examined the skills based on the content and summarized them into 5 items.

#1. OS (Windows, Unix, etc.)
#2. PLC
#3. Security measures in FA environment
#4. Network configuration
#5. Attack methods against FA equipment

Table 4 shows the results and differences in the mean scores of the skill checks conducted before and after the workshop for the seven participants of the machine control security course before and after the workshop. Since the exercises in this workshop were conducted about control security using a PLC, the skill of #2, #3, and #5 were improved. From these results, it can be said that the workshop was effective.

Table 4. Results of skill check in K-SEC security winter school (PLC exercise, Number of participants: 7)

#	Before workshop (Mean value)	After workshop (Mean value)	Difference
1	3.57	3.71	0.14
2	1.57	3.00	1.43
3	1.28	2.14	0.86
4	2.57	2.86	0.29
5	1.14	2.14	1.00

Information crisis management exercise for KOSEN (1/11/2020-1/12/2020 at Kochi College)

This workshop is a practical exercise for the participants to become system operators and to deal with the various incidents that occur along with the scenario appropriately and to tackle the stable system operation. Also, the exercises include telephone calls to users, which require not only specialized skills but also general skills. Based on the content, the skills were reviewed and summarized into 9 items.

#1. OS (Windows, Unix, etc.)
#2. Service
#3. Monitoring of service availability
#4. Network configuration
#5. Types of incidents such as security incidents
#6. Vulnerability of the system
#7. Situation of the whole system at the time of the incident
#8. Inquiries from users and related parties

Table 5 shows the results and differences in the mean scores of the skill checks conducted before and after the workshop for the nineteen participants. Although the level of difficulty is high as the workshop, the content of the workshop requires a wide range of skills in system operation, so we could confirm the overall improvement of skill levels and the effectiveness of the workshop.

Table 5. Results of skill check in information crisis management exercise for KOSEN (Number of participants: 19)

#	Before workshop (Mean value)	After workshop (Mean value)	Difference
1	2.74	2.95	0.21
2	2.11	2.84	0.73
3	1.84	2.79	0.95
4	1.84	2.47	0.63
5	1.68	2.79	1.11
6	1.84	2.74	0.9
7	1.58	2.63	1.05
8	1.63	2.84	1.21

Conclusions

A total of five skill checks were carried out in four workshops for students held in K-SEC. As a result, we observed an improvement in the skills related to the content in all workshops. Workshops held in K-SEC were effective in improving students' skills. It is also possible to formulate a hypothesis that it is possible to quantitatively confirm the effects of education through skill checks even when proficiency cannot be measured by tests. We would like to make use of the findings of this study to examine how to confirm the effectiveness of workshops and teaching materials in K-SEC.

Acknowledgements

We appreciate all the people who participated in the skill check.

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The Grand Design of English Education for the Global Engineer Program at NIT, Suzuka College

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Abstract

In 2017, National Institute of Technology (KOSEN), Suzuka College, launched the project, "the Global Engineer Program," to develop engineers with a global mind-set as well as state-of-the-art engineering knowledge and techniques. English should be required as a matter of first priority to accomplish the goal of this project. We have been struggling to improve students' proficiency in English. However, according to the Survey on KOSEN Graduates' Careers in 2015, 60% of them felt that they were not good at English in their college days and 83% of them indicated after graduation that they should have studied English harder in comparison to math, science or engineering.

Since the fall semester of 2006, we have already implemented new platforms of English communication class or presentation-oriented class by native speakers, based on small group learning by English proficiency, in the 3rd year or the 1st year advanced course. Actually these educational formats are highly reputed by students and motivate students to some extent to learn English, but they have only limited effects in their continuous English learning. Thus, while we didn't have follow-up classes in subsequent years, we felt the necessity to raise the level of the 1st year students who are not good at English.

Prior to the implementation of the Global Engineer Program, we reconstructed the deployment of English classes to be put into practice by seven consecutive years of education (in the five-year regular course and two-year advanced course). First, we incorporate grouping by English proficiency into the 1st year English class to motivate and encourage students to learn English corresponding to their proficiency. Then we conduct TOEIC preparation class in the 4th year, grouping by English proficiency, to score up by each level under the integrated syllabus and common educational platform, not depending on each teacher's discretion. Furthermore, along with the Global Engineer Program, we start new classes to more practically develop students' English competence: speech, discussion and debate, as global engineers. The purpose of this paper is to discuss the educational effects of the grand design for 7 consecutive year English education required for global engineers, focusing on the details of each class.

Keywords: *Program for global engineers, Project based learning, Educational effect, Grouping by English proficiency, Practical English communication, Presentation-oriented class, Small group learning, Motivation for learning English, TOEIC, TOEFL*

Introduction

In 2017, National Institute of Technology (KOSEN), Suzuka College, launched the project, "the Global Engineer Program," to develop engineers with a global mind-set as well as state-of-the-art engineering knowledge and techniques, due to the acquisition of competitive funds, "KOSEN Initiative 4.0." Since then, Suzuka College has promoted the enhancement of educational programs, including English education, related to "the Global Engineer Program," as Nobumitsu Hirai reported in "Educational Program for Future Global Engineers in NIT, Suzuka College."

Unfortunately, in general, engineering students tend to feel that they are not good at English, compared to math, science or engineering. Actually, as Figure 1 and 2 show, 60% of KOSEN students didn't study English as much as other subjects related to engineering and 83% of them after graduation felt that they should have acquired more English skills. The survey indicated that they considered English significant for engineering, but they were not supposed to know what to do or how to do English study even though they had an opportunity to learn.

The purpose of this paper is to focus not only on the methodology of English classes in each year but also on the effect of the class deployment on students' motivation. This paper is also to consider and explore the future perspective of the grand design of the seven-year English education at Suzuka KOSEN.

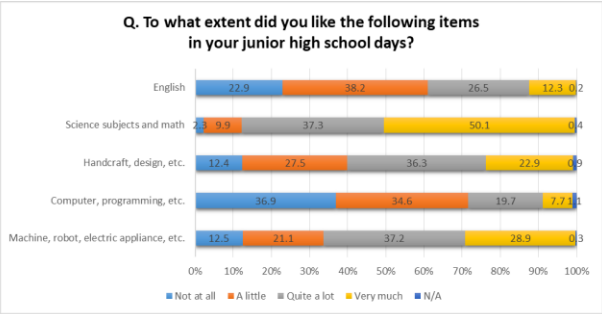


Figure 1 The Survey on KOSEN Graduates' Careers

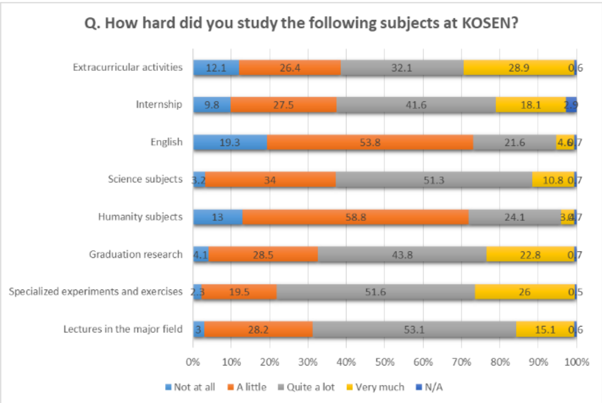


Figure 2 The Survey on KOSEN Graduates' Careers

The Grand Design of 7-year English Education

Figure 3 shows about 60% of KOSEN students have already felt they are not good at English in junior high school. One of the reasons students favour applying for the KOSEN is that learning English is not stressed but rather the acquisition of craftsmanship or manufacturing skills, so-called "monozukuri" skills, and specialized subjects related to engineering.

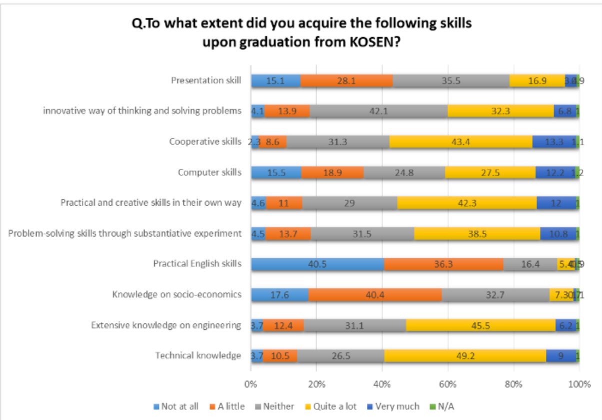


Figure 3 The Survey on KOSEN Graduates' Careers

Thus, prior to the Global Engineer Program, we tried hard to implement various English-class formats and content in order to motivate and encourage students to learn English. For example, in the fall semester of 2006, we incorporated a new English-class platform based on small group learning by English proficiency, into the regular curriculum of the 3rd year and the 1st year advanced course. This platform is adopted to English communication class in the 3rd year and presentation-oriented class in the 1st year of the advanced course. Each group has one native speaker to teach. As a series of our papers on these class formats demonstrated, these educational formats are highly reputed by students and motivate students to some extent to learn English, but they have only limited effects in their continuous English learning.

This is likely because we didn't have follow-up classes in subsequent years. On the other hand, particularly in the 3rd year class, there had already been a difference in English ability among students though they enjoyed the class activities in English. Due to grouping by English proficiency, students were able to have oral communication in English corresponding to their level. However, it was not adequate in brushing up other English skills later such as writing, presenting, or academic reading. We felt the necessity to develop a basics of English skills such as reading, speaking, listening, writing or grammar in the lower years, and especially to raise the level of the 1st year students who are not good at English.

In general, in Japan, the content of each class depends on each teacher's discretion as far as we conduct classes along with Ministry's Curriculum Guidelines. Although we succeed what we have done to the subsequent year in the short-term, we can hardly share a long-term perspective for English education at Suzuka KOSEN. Then we reviewed and reconstructed the deployment of English classes to be put into practice through seven consecutive years of education (in the five-year regular course and two-year advanced course). First, in addition to the 3rd year class, "Special Course of English II," we incorporate grouping by English proficiency into the 1st year English class to motivate and encourage students to learn English corresponding to their proficiency. Then we conduct TOEIC preparation class in the 4th year, grouping by English proficiency, to score up by each level under the integrated syllabus and common educational platform.

As an opportunity of the Global Engineer Project with the reorganization of the Advanced Course in 2017, we launched three new English class formats such as "Communication English I" for the 4th year, "English Commination II" for the 5th year and "Advanced English Conversation" (current name, "Language and Style in. English") for the 1st year of the Advanced Course. The new curriculum for the 5-year regular course is adopted for students of 2020.

Toward the purpose of the Global Engineer Program to train and nurture engineers with a global mindset as well as the cutting-edge knowledge and techniques of engineering, we work on constructing 7-year English educational programs. What English skills are required for students as global engineers upon graduation is not just to communicate with others in English but to give a logical presentation and have a discussion or debate with others on their own major field in English. Finally, our English programs will open up the vistas of going abroad to study at graduate schools or working in foreign institutions as one of the career paths for students.

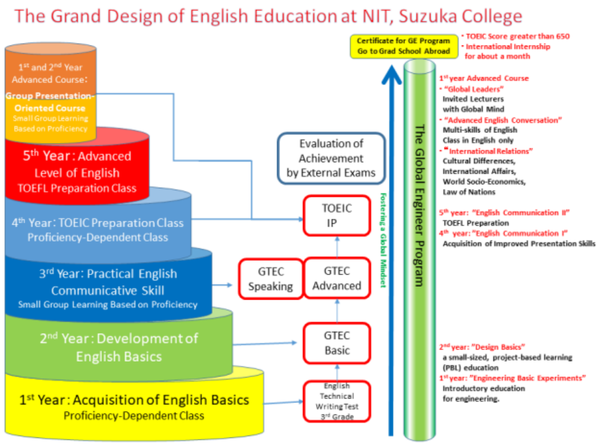


Figure 4 The Grand Design of English Education

Figure 4 illustrates the configuration of 7-year English education at Suzuka KOSEN. The English Programs in each year has a close relation to the Global Engineer Program. Furthermore, considering the grand design of English education, it is necessary to introduce external tests to evaluate students' achievement at each year.

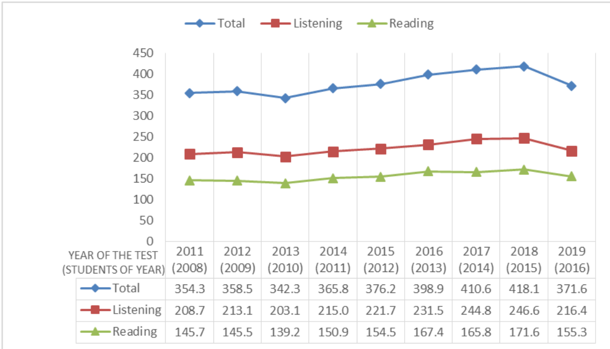
Grouping by English Proficiency for the 1st Year English Class

We launched a proficiency-depended English for 1st year students in 2017. We have two courses of English in the 1st year: one is for reading and the other is for grammar. While reading class is conducted once a week, grammar class is administered twice a week. One of the grammar class hours is allotted to proficiency-dependent class. As there are five departments at Suzuka KOSEN, all 1st year students are divided into five classes by the score of an external English test held soon after enrolment. This makes it possible to implement proficiency-dependent English class at the same time.

The Ministry of Education, Culture, Sports, Science and Technology (MEXT) has positively promoted oral-based English class since 2012. Related to this policy, it finally incorporated English class in the regular curriculum of elementary schools in 2020. Due to the widespread of oral-based English class at junior high schools, students have gradually become less hesitant to speak English with native speakers in the class.

However, the more oral-based English class is increasing, the less opportunities students supposedly have to learn basics of English skills such as grammar and reading. Suzuka KOSEN implemented oral-based English class by the full-time of native speaking teacher in 2005 ahead of MEXT's policy. We deliberately moved the oral-based class from the 1st year to the next year onwards and concentrated intensively on the improvement of English basics such as grammar.

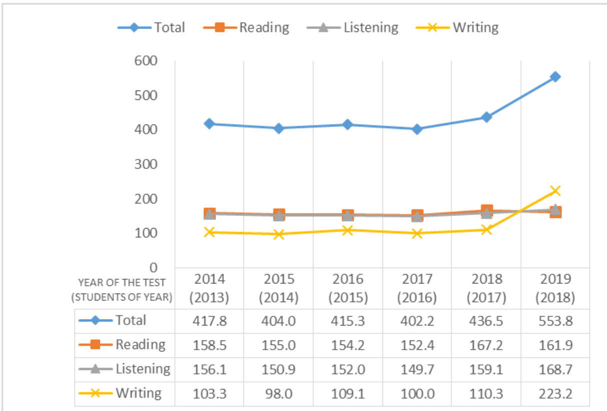
Actually, although, in 2012, MEXT increased the number of vocabulary to learn in junior high school from 900 to 1200 words, they divided them into receptive ones: words that a person can recognize and understand upon hearing or reading them, and expressive ones: words that a person can express or produce by speaking or writing, and focused on expressive vocabulary rather than the receptive. Figure 5 shows the transition of the TOEIC average score in the 10 years at Suzuka KOSEN. The score does not include that of international students. It indicates that the TOEIC score of students of 2016 largely dropped though the score had been continuously increasing. The year of 2016 was the first when KOSEN adopted the exam format of multiple choice only for the entrance exam. Our anxiety in regard to insufficient basics of English came from changing the exam format. As for the 4th year English class format, it will be referred to later.



YEAR OF THE TEST (STUDENTS OF YEAR)	2011 (2008)	2012 (2009)	2013 (2010)	2014 (2011)	2015 (2012)	2016 (2013)	2017 (2014)	2018 (2015)	2019 (2016)
Total	354.3	358.5	342.3	365.8	376.2	398.9	410.6	418.1	371.6
Listening	208.7	213.1	203.1	215.0	221.7	231.5	244.8	246.6	216.4
Reading	145.7	145.5	139.2	150.9	154.5	167.4	165.8	171.6	155.3

Figure 5 Transition of the TOEIC average score in the 10 years

Then, Figure 6 and 7 indicate the effect of before and after proficiency-dependent class. The average score of GTEC Basic and Advanced is obviously increasing after students of 2017 onwards.



YEAR OF THE TEST (STUDENTS OF YEAR)	2014 (2013)	2015 (2014)	2016 (2015)	2017 (2016)	2018 (2017)	2019 (2018)
Total	417.8	404.0	415.3	402.2	436.5	553.8
Reading	158.5	155.0	154.2	152.4	167.2	161.9
Listening	156.1	150.9	152.0	149.7	159.1	168.7
Writing	103.3	98.0	109.1	100.0	110.3	223.2

Figure 5 Transition of the GTEC Basic average score in the 6 years

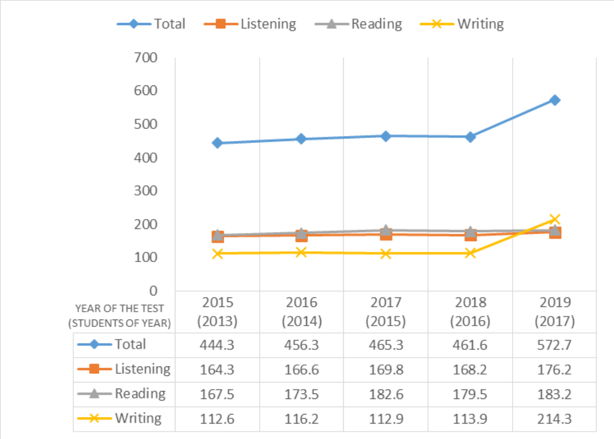


Figure 6 Transition of the GTEC Advanced average score in the past 5 years

We hold the Global Test of English Communication (GTEC) as an external exam to access the achievement of students. GTEC Basic is for 2nd year students; GTEC Advanced is for the 3rd year students. GTEC consists of four skills test: listening, reading, writing and speaking, and is widely used to access English communicative abilities of high school students throughout Japan. This time we use the total score except the speaking test as the evidence of students' achievement. It is because we don't conduct a speaking test for 2nd year students.

If that helps, according to Benesse Co., which develops GTEC, the nationwide average score of GTEC Basic is usually about 445 and that of GTEC Advanced is about 465. Compared with these nationwide average scores, this class format stimulates students to study English harder.

The proficiency-dependent class is not fixed for a whole year, but it is recomposed by term-exams. As a result, this fluid class composition encourages a spirit of emulation among students and motivates them to study harder to keep their position or advance to the upper class. On the other hand, we can make the content more difficult or easier corresponding to the class level. Furthermore, it makes it possible for us to intensively look after students who are poor at English and review the content of junior high school in some cases.

Grouping by English Proficiency for the 3rd, 4th Year and 1st Year Advanced Course English Class

We have already publicized what we have done on English education many times. Here we introduced the purposes of these classes along with the past papers.

In the fall 2006 and spring 2008 semesters, we incorporated small group learning class based on English proficiency into the regular curriculum for 3rd year and 1st year advanced course students, respectively, as part of the diversification of the English educational program in order to motivate students to learn English. At that time this platform had rarely been implemented in Japan.

The purpose of this class platform was to motivate students to acquire practical communicative skills with English native speakers. Additionally, our emphasis on small group English learning acted as a catalyst for the creation of an English presentation course for advanced course students.

Figure 8 Small group learning class in 3rd year

The expected educational effects of the class platform were to provide students with better opportunities to develop practical English communicative skill through actual teaching by native English speakers, to promote efficient learning along with each student's proficiency, and to encourage interest in English learning and motivation to continuously study English.

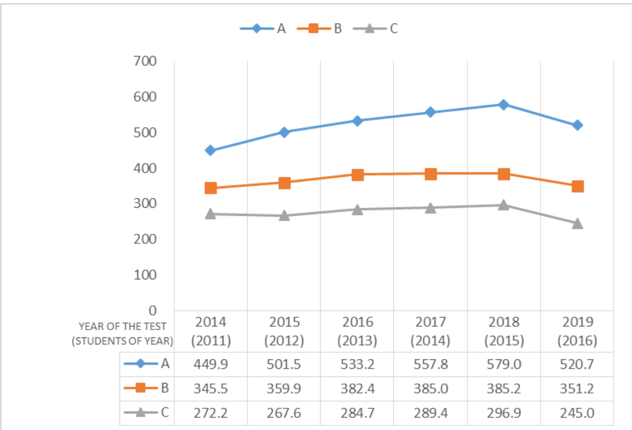
In contrast with the 3rd year class's main concern of English oral communicative skills, 1st advanced course students were constructed with the main goal being to create and give professional-level oral presentations in English. It was expected that the acquisition of English oral presentation skills would add real value to the academic arsenal of our students as they went forth into the job market or on to universities.

Figure 8 Presentation-oriented class in 1st year advanced course

According to the annual survey on the evaluation of the class, this platform has been highly reputed among students since it launched. The small group learning classes based on English proficiency in the 3rd year and 1st year advanced course are still the core programs, considering the grand design of English education at Suzuka KOSEN.

As we examined before, there was a significant difference between students who took the TOEIC preparation class and those who didn't. It proved that the class has a good influence on the increase of the TOEIC score. However, as the class had been intermittently conducted for 4th year and 3rd year students within one teacher's own discretion, the effect was limited.

As more universities replaced the transfer English exams with the TOEIC or TOEFL score, more and more students hoped for the TOEIC preparation class. Furthermore, the TOEIC score became used as one of the external evaluations more and more. In 2014, we finally decided to launch the TOEIC preparation class for 4th year English classes to increase the scores by each level under the integrated syllabus and common educational platform without depending on each teacher's discretion. This course is constructed as a proficiency-dependent class, dividing students into three levels based on the GTEC advanced score in the previous year. Compared to the average score of KOSEN students, 361, or that of 1st year university students (equivalent to 4th year KOSEN students), 439, as Figure 9 shows, this class format greatly contributes to the increase of the TOEIC score at every level. Even the score of students of 2016 is higher than that of students of 2014, who were the first to take the TOEIC preparation class.



YEAR OF THE TEST (STUDENTS OF YEAR)	2014 (2011)	2015 (2012)	2016 (2013)	2017 (2014)	2018 (2015)	2019 (2016)
A	449.9	501.5	533.2	557.8	579.0	520.7
B	345.5	359.9	382.4	385.0	385.2	351.2
C	272.2	267.6	284.7	289.4	296.9	245.0

Figure 9 Comparison of the TOEIC average score at each level

We have continuously improved the English class formats or content since some time ago, but we strived to achieve the goals imposed only on the target class or year. Thanks to the Global Engineer Program, we can draw a line to connect the dots. We can make the most of what we have done.

Newly Established English Courses Related to the Global Engineer Program

We newly established three courses in the 4th year, 5th year and 1st year advanced course, related to the Global Engineer Program. "Advanced English Conversation" in the 1st year advanced course has already been conducted since 2017. In 2020, "English Communication I" just started for 4th year students. In 2021, "English Communication II" will launch in 5th year.

As for "Advanced English Conversation," the gaol is to develop students' English communicative competence as global engineers on the premise of group presentation-oriented class taught by the native English speaker. To accomplish this goal, students are expected to develop and acquire the multi-skills of English such as speech, discussion, and debate. In addition to the acquisition of the multi-skills of English, students will gain a broader understanding of global issues. Topics range from cultural and social diversity to matters related to engineering while improving their communication, listening, reading, writing, and presentation skills in English. As this course is not just for English conversation, the class name changed into "Language and Style in English" correlating to the class content.

"English Communication I" is an elective subject, but it is compulsory for the candidates of the Global Engineer Program. The objective of this course is to provide students with many opportunities to practice creating and giving English-language speeches based on the well-established pedagogical method of extemporaneous speaking, as well as to offer students practice creating and engaging in persuasive, motivational, and informative speeches. Succeeding to the acquisition of practical English communicative skill in the 3rd year, students are expected to acquire a higher presentation skill required for the international conferences or business scenes.

"English Communication II" is also an elective subject, but it is compulsory for the candidates of the Global Engineer Program. However, this course has already moved up the schedule to be held under the name of "English V" since 2020. This course aims to give students a comprehensive overview of the speaking and writing sections of the TOFEL iBT. This course provides detailed explanations of each of the unique question types and information on how each type will be assessed, focused vocabulary and test taking strategies that can help to make students a more efficient and capable test taker. As TOEIC is not sufficient to apply for universities abroad, this course will broaden students' career options including going to the graduate school abroad.

Although both "English Communication I" and "English Communication II" were launched in 2020, the widespread of COVID-19 throughout the world forced them to be conducted online. We had to make a big change to the expected programs.

Conclusions

Thus far, we have been able to accomplish certain results through our English programs. Now, however, we are still working on progressing and need to continuously review and validate the practicability of the grand design of English education at Suzuka KOSEN.

The year 2020 should be a turning point for the Global Engineer Program to start a new curriculum. As students of 2020 advance to next years, the number of classes including English is gradually decreasing because of attrition. As for English courses, we should not undermine educational quality but rather enhance the content of the courses. For example, we should take into consideration the implementation of team-teaching with the native and non-native speakers. As there still remains a bad habit of education in Japan, it has been difficult for us to cooperate with other teachers beyond each teacher's discretion. The Global Engineer Program also requires us to reconsider the way of teaching.

The widespread of COVID-19 was unexpected, but tough times bring opportunities to reconsider what we have to do. Thanks to this, we all are forced to accommodate ourselves to online classes. It will contribute to the coming English platforms soon.

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Practice of Cybersecurity Education with Development of Educational Materials in the K-SEC Project

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Abstract

As the reach of information and communications technology continues to extend to every corner of modern society, experts are increasingly needed in the field of cybersecurity. However, there is a shortage of human resources in this field.

Since 2015 the National Institute of Technology (KOSEN) has promoted the development of cybersecurity expertise by dividing Japan into five blocks that each contains a base college and practical colleges focused on cybersecurity. The project is known as the KOSEN Security Educational Community (K-SEC). This project provides an environment in which students as young as fifteen or elder can be exposed to the latest hardware and software to continually produce human resources with cybersecurity competencies.

K-SEC has two scopes. One is to produce a large number of graduates from technical colleges who possess the advanced skills required to work as cybersecurity specialists. Another is to provide students with an awareness of security and technology necessary for experts in engineering fields related to machinery, construction, civil engineering, electronics, materials, and life sciences. Further, K-SEC aims to teach information technology engineers about society's needs for cybersecurity. Ichinoseki College, which is one of the K-SEC base colleges, has been undertaking in various efforts to achieve these goals.

In response to the latter purpose of K-SEC, Ichinoseki College has produced basic course materials on security for all departments. This involved the development of web-based learning materials regarding information ethics. The materials were designed for e-learning tests and group work discussions on various information security issues. In this paper, we discuss the related concrete educational activities and their effectiveness.

Keywords: *Cybersecurity Education, Information Ethics Education, Development of Educational Materials*

1. Introduction

Since 2015, the National Institute of Technology (KOSEN) has been working on an education project that aims to nurture human resources in the information and communication technology (ICT) industry, especially in the field of cybersecurity [2, 3, 4, 5, 6, 7, 8, 9]. The project is called the Kosen Security Educational Community (K-SEC), and as of 2020, it has been joined by 20 colleges. Our college joined K-SEC in 2016 as a base college and has worked to develop content for information security education.

Figure 1. K-SEC homepage [11]

K-SEC has two main purposes (see Fig. 2). One is "quantitative improvements"—developing outstanding cybersecurity personnel—and the other is "quantitative expansion"—systematically providing students with security knowledge.

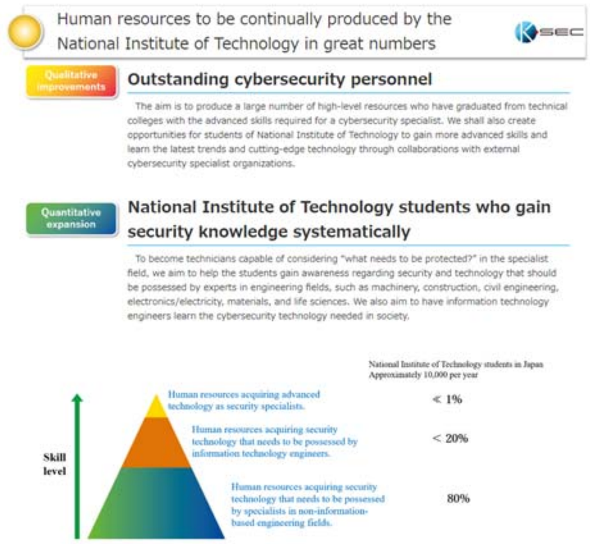


Figure 2. Human resources to be produced
(K-SEC website)

The main activities of K-SEC are the following:

1. Creation of human resource image and curriculum
2. Creation of educational materials and rollout to colleges nationwide
   - Deployment of exercise-based course materials on security
   - Holding contests and conducting advanced resource nurturing courses and other activities
3. Preparation of security exercises rooms
4. Forming security-related communities
   - Holding training courses and workshops
5. Connections between security-related external organizations

One of the primary activities of K-SEC mentioned above is the creation of educational materials and rollout to colleges nationwide. We have created the "*basic course materials for all departments*" for learning security basics and "*course materials for information-based students*." In the course materials in each specialist field within the basic course materials for all departments, we have prepared case-based learning content that allows students to acquire security knowledge that is useful in real society. These materials are referred to as "*K-SEC educational materials*."

Additionally, we have developed exercise-based course materials with external organizations to help students understand the necessity of cybersecurity. We have prepared course materials that allow students to enjoy and experience cybersecurity through exercises that involve cloud-based environments, board game-format exercises, and card games in the IoT field. We call these materials "*K-SEC related educational materials*."

All of the educational materials are shared with colleges nationwide on the website SharePoint in Microsoft 365®.

2. Materials and Methods or pedagogy

In this section, we first introduce the developed educational materials related to cybersecurity, then present our practices utilizing the materials.

2.1 Development of Educational Materials

As mentioned in the previous section, there are two major types of the K-SEC educational materials. One is "basic course materials for all departments" and the other is "course materials for information-based students." Here, we introduce the former in detail.

The basic course materials consist of the following.

1. Information ethics educational materials
2. Information and computer literacy educational materials
3. Course materials in each specialist field; case-based learning content for acquiring security knowledge that is useful in real society.

We have primarily been involved in the development and utilization of "Information ethics educational materials." In 2015, the K-SEC project created "information and computer literacy educational materials" and "course materials in each specialist field." We found that there was much demand for the development of information ethics educational materials for fundamental security education in lectures related to information literacy and for guidance in extracurricular activities, which are sometimes referred to as Long Homeroom before summer break.

The specific contents of the materials are shown below. Information ethics educational materials are composed of the following three types of content.

A) E-learning materials for self-directed study

1. A Test for Guidelines for Using Social Media
   - The test consists of a set of 10 multiple-choice questions
2. A Test for Guidelines for Using Personal Devices for School-Related Business
   - The test consists of a set of 10 questions
3. A Test for Information System User Guidelines
   - The test consists of 4 sets of 10 questions each

Figure 3. An example of a quiz:
"Important points for using social media"

Figure 4. An example of a quiz: "Basic concepts for using social media"

Note that the tests differed from general tests in that more than one answer for each multiple-choice question was correct. In a sense, it was more difficult to choose all the correct answers than usual.

B) Microsoft PowerPoint and Word materials for group work

This section refers to PowerPoint materials for teachers to present and Word materials for students to discuss in practicing group work.

Figure 5. An example of a slide: "Password management"

Figure 6. An example of a slide: "Ransomware"

Each material theme has 15 topics in the following manner.

1. Computer viruses
2. Countermeasures against phishing fraud
3. USB memory device management
4. Copyright
5. Email attachments
6. Is wireless LAN dangerous?
7. Password management
8. OS and software updates
9. Ransomware
10. Personal information and social media
11. Malware infection
12. Tech support scams
13. Unauthorized Computer Access Law
14. Penalty on computer virus creation
15. The risk of a Haney trap

C) Microsoft Excel material for the assessment of teaching effectiveness

The last materials were prepared to identify how students' awareness changed after learning about information ethics in the field of cybersecurity. The assessment items comprise 50 questions in total; 10 questions each for "Guidelines for Using Social Media" and "Guidelines for Using Personal Devices for School-related Business" and 30 questions for "Information System User Guidelines."

Each question could only be answered with "Yes" or "No." For instance, "Do you understand the appropriate attitude to assume when using social media?" or "Can you list dangerous situations (examples) when using social media?". These assessment item lists can be imported into e-learning systems.

Figure 7. Students' awareness survey

2.2 Practice of Cybersecurity Education

In this subsection, we present two practices of cybersecurity education utilizing the developed educational materials. Both practices were conducted with approximately 160 first-year students in 2019.

A) Utilizing e-learning materials for self-directed study

Students independently work on tasks from Step 1) to Step 4) below. All tasks can be completed using the e-learning system "Moodle" in a web browser.

1. Answer survey questions on attitude toward social media before learning. The survey includes 10 questions about "Guidelines for Using Social Media" and is provided on the e-learning system. Answer results are automatically totaled.
2. Watch video teaching materials regarding issues that arise in the use of social media. The materials are available on the official website of the Information-technology Promotion Agency, Japan; IPA Channel (ipajp) on YouTube [10]. For example, a title of one of the materials is "Knowledge of the proper use of social media."
3. Learn with e-learning educational materials. The materials for self-directed study are "Guidelines for Using Social Media" and a confirmation test is also prepared at the end of it.
   The teacher advises students to keep trying until they obtain a perfect score.
4. Answer survey questions on attitude toward social media after learning again. The questions are identical to those of Step 1).

B) Practice instance utilizing materials for group work

The teacher first explains how students should complete the group work and provides an outline of the 15 topics of the PowerPoint materials. Subsequently, students work on tasks from Step 0) to Step 6) below in order. Each task can be performed by using a laptop PC, tablet device, sticky note, and poster paper.

Figure 8. Explanation of Group Work

0. Ice Breaker (Students introduce themselves).
1. Each groups chooses a theme to discuss from the 15 topics in materials for group work. Each group is composed of 4 or 5 students.
2. Each student thinks about an incident related to information security and dig up the problems on the rules at each topic respectively.
3. Students share the problems with each other in the group.

Figure 9. Sharing Ideas during Group Work

4. Students think of new rules to solve the problems and then make a PowerPoint slide.
5. Each student shares new rules with other groups using ICT as form of a presentation. Simultaneously, students in the audience evaluate the presentation.

Figure 10. Presentation using iPad Air

6. Finally, each student evaluates each group's presentation

Note that this practice is held at the security exercise bases, which is prepared as one of the main activities in K-SEC.

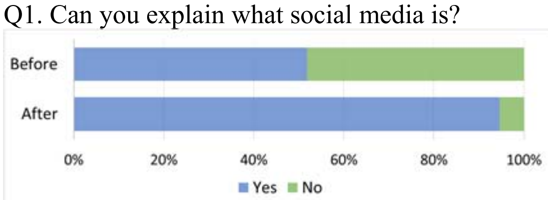
3. Results and Discussion

In this section, we consider the educational effects of the practice instances described in the previous section.

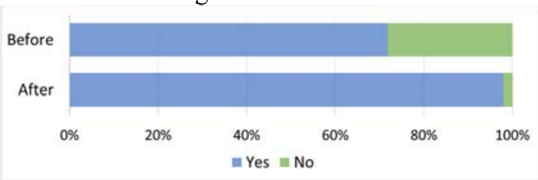
A) Evaluation of self-directed study

The results of the survey questions are shown below. We show students' responses to six of the ten questions.

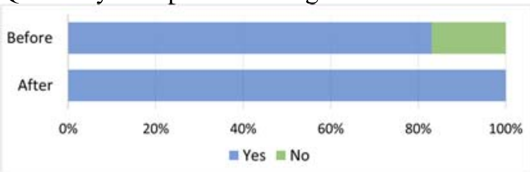
Q1. Can you explain what social media is?



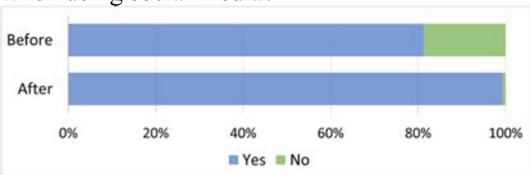
Q2. Do you understand the appropriate attitude to assume when using social media?



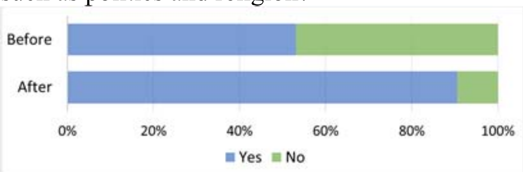
Q3. Can you explain the dangers of social media?



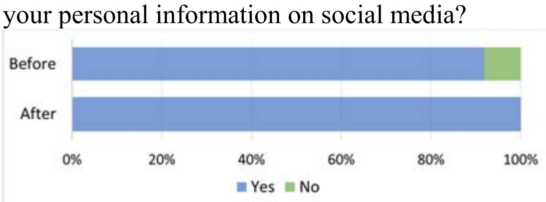
Q4. Can you list dangerous situations (examples) when using social media?



Q5. Can you explain the points to keep in mind on social media regarding the beliefs of individuals such as politics and religion?



Q6. Can you explain why you should not share your personal information on social media?



The survey above shows that for all the questions, the rate at which students answered yes increased after learning. For Q1, Q2, and Q5, the rate of answering yes increased significantly, and for Q3, Q4, and Q6 the rate increased to almost 100%. These results show that students' understanding improved after the learning activities.

Next, we examine students' evaluations of the educational materials.

◆ Question:

Please write your impressions about the content of the teaching material and social media

◆ Answers:

Excerpts from some of the students' answers are presented below. Note that some sentences have been paraphrased.

- ➢ I am going to be careful not to post my personal information online.
- ➢ I find that it is important to correctly understand the benefits and risks of social media.
- ➢ I am scared of being involved in arguments or slander.
- ➢ The explanation in the teaching material is easy to understand.
- ➢ Quiz and illustrations are provided based on case studies, which allowed us to learn very easily.
- ➢ It is good to be able to learn using the materials repeatedly.
- ➢ Every time I studied, the order of the problems and the answer choices changed, which I found helpful.

The first three responses concern changes in students' awareness regarding basic concepts when using social media. The last four are related to students' evaluations of the learning materials. As shown, most of the students' responses were positive.

B) Evaluation of the group work

◆ Question:

Please write what you learned and felt through the group work.

◆ Answer:

Excerpts from some of the students' answers are presented below. Note that some sentences have been paraphrased.

- ➢ I learned about the importance of passwords more concretely.
(Theme: Password management)
- ➢ We should only connect to a public wireless LAN after confirming that it is safe.
(Theme: Is wireless LAN dangerous?)
- ➢ I learned about anti-phishing measures.
(Theme: Countermeasures against phishing fraud)
- ➢ I would like to work in an information technology-related field in the future, and I gained an interest in security.
(Theme: Ransomware)
- ➢ The most impressive lesson was, "No matter how many measures you take, measures are not always perfect."
(Theme: Computer viruses)
- ➢ Group work was meaningful because each group had a different perspective.
- ➢ I noticed things that I would not have noticed alone and gained new knowledge.
- ➢ I thought it was important to concentrate on listening to the presentation.
- ➢ I was able to practice speaking in front of people.

- ➢ It turns out that it is easy to put together an idea but hard to convey it to others.
- ➢ The atmosphere was different from that of usual classes, so it was fun.
- ➢ I found that there were a lot of things to learn, such as presentation attitudes and methods, in addition to the course content.
- ➢ I think this group work will lead to my growth, so I will actively participate in the future.

Most of the students' answers were positive. The first five responses were related to students' awareness of security issues. The remainder concerned their attitudes when participating in group work and giving presentations.

Our students analyzed a security incident and identified the problem in each theme in cooperation with other students. They then devised possible rules against each problems in cybersecurity. The self-evaluations confirmed that their skills grew through group work.

4. Conclusions

In this paper, we introduced the development of educational materials and presented an example of the educational practice in which they were utilized and subsequently analyzed their effects. The students' comments and questionnaire survey results show that our efforts to develop cybersecurity education materials were successful. Future tasks are to update materials continuously while incorporating recent topics and consider methods for measuring the educational effects other than questionnaire surveys.

Acknowledgements

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E-PORTFOLIO: AN EXPLORATORY INVESTIGATION OF LEARNERS' PERCEIVED VALUE OF LEARNING

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Abstract

The many affordances of electronic portfolios (e-portfolio) have been widely discussed in literature to help learners enhance their reflection skills, promote provision of feedback and to synthesise learning experiences. Despite extant literature acknowledging e-portfolio as a sound pedagogical learning tool, it remains challenging for e-portfolio to exist effectively for learning. Some of these challenges include learners' acceptance and rejection of the e-portfolio platform, in terms of its (1) perceived ease of use, (2) perceived usefulness as well as learners' perceptions of the value of learning through their (3) perceived processes of learning. This paper attempts to evaluate the perspective of learners in the value of learning that e-portfolio can offer in a cluster of three lessons in a module in a polytechnic. Learners' perceptions of ease of use, usefulness and process of learning in using the e-portfolio were garnered. Specifically, the learning application tool, Padlet, was adopted as the e-portfolio platform in the described module. This study employed a cross-sectional design using an online survey consisting of 23-items. The survey items were adapted and reviewed from scales of existing literature such as the technology acceptance model (TAM). 6 items were in each of the constructs of perceived learning process (PLP), perceived value of learning (PVL) and perceived ease of use (PEU) while 5 items were in perceived usefulness (PU) construct. In total, 792 students took part in this study. The data collected from the survey were analysed and found to display high internal consistency with Cronbach alpha value of .97 and item-total correlation in the range of .62 to .83. In addition, a correlational study suggested that all constructs was highly positively correlated with one another. Moreover, multiple linear regression analysis revealed a significant model with the independent variables explaining 90% of the variability in perceived value of learning in learners. However, perceived ease of use was not a significant predictor of perceived value of learning. Based on the findings, it is crucial for the module team to enhance the ease of use of the e-portfolio in improving learner's perceived value of learning via the e-portfolio.

Keywords: *E-portfolio, Padlet, perceived learning process, perceived ease of use, perceived value of learning*

Introduction

By the affordances of digital media, electronic portfolio (e-portfolio) made ubiquitous learning possible through its accessibility and functionality in allowing learners to document their learning and carry out reflection. In particular, there has been an extensive body of literature delving on the benefits of e-portfolio implementation for learners' learning in the higher education setting (Garrett, 2011; Luera, Brunvand, & Marra, 2016; Pei-Hsuan Hsieh, Chun, & Wei-Fan, 2015). E-portfolio has been useful in helping learners to perform the different broad stages of learning collectively as described in Bloom's taxonomy, namely: (1) understand, (2) apply, (3) analyse, (4) evaluate and (5) synthesize (Krathwohl, 2002). From the learners' perspectives, e-portfolio provides a convenient platform to collate their learning, make connection between theories and practices as well as enhance transferability of insights across different disciplinary domains such as IT courses, nursing and midwifery education and MBA courses (Birks, 2016; Ciesielkiewicz, 2019; Garrett, 2011). From the educator's perspectives, it will be easier to monitor and track the learners' learning progresses through a common e-portfolio platform. Formative timely feedback can also be provided to learners to achieve the optimal learning effect. In a problem-based learning (PBL) classroom, self-regulation and reflection are essential stages of learning for learners to be involved in before self-directed learning can be demonstrated. In this aspect, e-portfolios have been shown to have the capability to assist learners in performing individual reflection as well as co-reflection with fellow teammates.

However, it is important to calibrate the potential benefits of e-portfolio use and the challenges that may surface as a result of its implementation. For example, the technology adopted as the e-portfolio is a main concern for learners (Birks, 2016; Ciesielkiewicz, 2019; Garrett, 2011; Luera et al., 2016; Pei-Hsuan Hsieh et al., 2015). Another difficulty encountered in the effectiveness in e-portfolio implementation lies in the mismatch between the expected benefits of e-portfolio and users' learning experience after using the e-portfolio (Birks, 2016).

While it is important to canvass the learner's perspectives in e-portfolio usage, it is equally crucial to garner the lecturers' perception in the e-portfolio experience. In particular, lecturers are concerned if the e-portfolio can help the learners to develop personally and collectively in a team. The practical aspects of e-portfolio implementation such as its ease of use in assisting lecturers to monitor learners' progress and assess learners' development are also pertinent in ensuring appropriate buy-ins from lecturers. However, the lecturers' perception of e-portfolio implementation is beyond the scope of this study.

In a critical thinking and problem solving module in a polytechnic in Singapore, learners made use of problem-based learning (PBL) approach in solving a problem that spanned over three lessons. E-portfolio has been advocated as a predominant tool to help support their learning. It is emphasized that this is the first time that an e-portfolio has been utilised in this module to support the learners' learning. Henceforth, this research is a preliminary study attempting to investigate the effectiveness of e-portfolio implementation in this context.

The main aim of this study has two-fold: (1) examine the technological perspectives of e-portfolio and (2) explore the perceived process and value of learning after going through the cluster of lessons using e-portfolio as a learning tool. Specifically, the following research questions were crafted to investigate the aims of this study as follows:

1. What are the perceptions of the learners towards the use of e-portfolio?
2. Are there significant relationships between the perceived ease of use (PEU), perceived usefulness (PU), perceived learning process (PLP) and perceived value of learning (PVL)?
3. To what extent do the perceived ease of use (PEU), perceived usefulness (PU) and perceived learning process (PLP) predict perceived value of learning (PVL)?

Different types of e-portfolios

Collectively, there are three main types of e-portfolio; (1) Developmental, (2) Reflective, and (3) Representational (Jaryani, Zandi, Sahibudin, Salehy, Masrom, & Zamani, 2010), Firstly, a developmental e-portfolio is a work in progress display of the work that the owner (learner) of the e-portfolio has accumulated over a period of time. Learners will attempt to link their work to the learning outcomes and criteria of assessment rubrics. Secondly, a reflective e-portfolio involves the learners making sense of what they have learnt and relating to authentic experiences. Explicit focus will be on the learners to perform self-reflection and to understand more about their strengths and weaknesses, i.e. realisation of self-competency. After which, the learner will be provided with opportunities to improve their work based on the feedback obtained from teachers and peers, as well as self-evaluation that was carried out after self-reflection. Lastly, a representational e-portfolio showcases the achievement of the owner with regards to their desired goals or the learning outcomes. As such, the work demonstrated in this portfolio is selective and represents the peak achievement of the owner as he progresses and develops over a period of time (Jaryani et al., 2010). In this present study, the hybrid of developmental and reflective e-portfolio is a more appropriate mode to be adopted in the described curriculum routine.

As evidenced, e-portfolio is not merely a simple collection or reposition of individual or group product of work. It should also be viewed as a medium to showcase the process of learning. In fact, Garthwait and Verrill (2003) argued that the underpinning concept of e-portfolio is centred on the learning process, rather than the product of learners. Similarly, Barret (2010) highlighted on the importance of the reflection and critical thinking displayed during the construction phase of e-portfolio.

E-portfolio platforms

There are many e-portfolio systems that are being used by schools, colleges and universities. Among the more commonly used ones are FolioSpaces, Blackboard ePortfolio, Digication ePortfolios, Mahara and Elgg. These are systems that are either incorporated using free hosting services, residing within an institutional learning management system or operating on open source. Padlet is an online application that allows users to create a bulletin board for organising and displaying of information. Images, links, pictures and videos can be added onto the Padlet learning canvas as digital evidence of students' learning which can then be shared with classmates or teachers. As such, Padlet is a powerful learning tool for tracking of students' learning progresses, promoting of self-reflection and self-directed learning. Despite these useful affordances, Padlet is not used traditionally as an e-portfolio pedagogical tool probably due to its lack of explicit scaffolding structure for students' learning. For the current study, a preliminary study will be conducted to evaluate the effectiveness of using Padlet as an e-portfolio platform as a scaffolding tool for learning.

Perceived ease of use and perceived usefulness

The technology acceptance model (TAM) developed by Davis (1985) is a robust and common framework used in investigating users' technology adoption behaviour (Rahmi, Burak, & Adnan, 2018). To ensure the effectiveness of the e-portfolio implementation in this study, first and foremost, there is a need to better understand the factors that influence learners' acceptance and rejection of e-portfolios. In this model, there are several connecting variables such as Perceived Ease of Use (PEU), Perceived Usefulness (PU), Attitude to use (AT) and Behavioural Intention (BI). According to Davis

(1989), PEU and PU are the most important sub-constructs in this model as they mainly influence an user's acceptance or rejection of the technology introduced (Abdullah, Ward, & Ahmed, 2016; Mu-Yen Chen, Mou-Te Chang, Chia-Chen Chen, Mu-Jung Huang, & Chen, 2012). PEU is defined as the extent to which the user of a particular system perceives that the system is easy to use. On the other hand, PU refers to the extent to which the user of a particular system believes that the usage would improve his work performance. PEU and PU are also extrinsic motivational belief factors in influencing users to continue using the adopted technology or system. In this current study, learners' PEU and PU will be examined and not the AT and BI variables for several reasons. Firstly, recent studies have revealed that the AT factor has a weak relationship with the other variables in the model and hence was excluded from the model (Bhatiasevi, 2011; Teo, 2009; Ursavaş, 2013). Secondly, from a meta-analysis conducted that examined user acceptance in e-learning systems, it was found that the relationship between the TAM variables and user satisfaction, rather than attitude, yielded the best results (Rahmi et al., 2018). Thirdly, insights obtained from studies on Asian students' perspectives on e-portfolio utilisation revealed that Asian learners might be more concerned with the practical aspects (i.e. displaying of capabilities and getting tangible assessment results) of using the e-portfolios while Western learners perceived e-portfolios as tools that can help them in self-reflection and learning evaluation (Mu-Yen Chen et al., 2012; Pei-Hsuan Hsieh et al., 2015). Hence, taken adherence from these findings, PEU, PU and the learners' perceived value of learning via their process of learning will be examined in further details in the evaluation of effectiveness of the newly implementation e-portfolio system.

Perceived learning process and perceived value of learning

As posited by Biggs (2001) in his 3P model (Presage, Process and Product), the approaches to learning in the learners' perspectives can be broken down into (1) Planning of learning behaviour (through prior knowledge, competence and learning preferences), (2) Learning process execution (for instance, engaging in reflection and linking concepts learnt) and (3) Product of learning (what the learners have achieved and their sense of learning satisfaction). Indeed, the process of learning is central to the dynamic teaching and learning system (Biggs, 2001). Measurement of perceived learning process will also allow insights about the quality of the educational experience of learners and provide opportunities for program designers to adjust and review subsequent implementations (Vaisman, 2012). In the investigation of 1490 students from University of Almeria and Granada (Spain) in an education programme, the teaching-learning process (TLP) of students was examined to identify the potential factors that affected students' satisfaction (Cardelle-Elawar, 2011). Besides gaining insights from the different personal and contextual factors that influenced students' perspectives of the TLP outcome, the study also revealed the systemic calibration between the teaching and learning processes. As evidenced, the significance of the learning processes of learners cannot be overly emphasized. It is also noteworthy that the "Product" phase in Biggs's 3P model described learners' experience in the different teaching contexts in different classes and disciplines. In this current study on learners' perception on e-portfolio, it will be more apt to use another measure to assess learners' take-away from the utilising of e-portfolio to support their learning.

In another study on exploring preschool and primary school education students' perception on the value/usefulness of e-portfolio, the value/usefulness subscale from the Intrinsic Motivation Inventory (IMI) from the self-determination theory hypothesized by Deci (1991) was adapted and used. The result findings revealed that students' perception on the value of e-portfolio was greatest influencing factor on intrinsic motivation, indicating a high tendency for students to be engaged and intrinsically motivated − essential for the successful implementation of an e-portfolio in the curriculum. In fact, the perceived ease of use variable, as mentioned previously, is also an important facet of learners' motivation. Hence, the measurement of perceived value of learning (PVL) is appropriate in this study as it is a construct, together with perceived of ease and perceived usefulness, relevant to the concept of learners' motivation (Deci, 1991). From the learners' perspectives, challenges with the use of e-portfolio as well as the satisfaction of the process of learning will in turn affect their motivation, either in a positive or negative manner (Kwok, 2011; Tuksinvarajarn, 2009). Taken together, the four constructs investigated in this study offer insights into the multi-faceted perception of learners towards the use of e-portfolio.

Background

In this study, the polytechnic of the investigated critical thinking and problem solving module specialises in the instructional approach of Problem Based Learning (PBL). In tandem with the socio-constructivist approach, learners in the polytechnic are given opportunities to activate their prior knowledge, construct new knowledge based on active engagement in information finding, scaffolding from facilitators, peer collaboration and reflection.

Specifically, for the described mandatory module for mainly Year 1 learners in the institution, they are exposed to concepts (such as claims and arguments, types of argument, various cognitive biases and logical fallacies) of critical thinking skills and dispositions (for instance, open-mindedness, scepticism and empathy) of good critical thinkers. Particularly, the structure of Lesson 10 to 12 is of a complex nature and the contexts mirror that of a real world complexity – terrorism. It allows the learners to make use of the concepts learnt in systems and critical thinking to help them address the controversies existing in a real life problem contexts. Consequently, in their teams, learners have the opportunities to conduct problem solving in an authentic-learning background infused with gaming elements. Henceforth, the design of this cluster of three lessons is deliberated towards being more ill-structured. It is also expected for the students to spend more time and effort in (1) unravelling the staggering information released every lesson, (2) selecting and piecing bits and pieces of information together, (3) developing deep engagement with the concepts and in turn (3) promoting reflection, independence in learning and internalisation of concepts.

Research design and participant

This quantitative study employed a non-experimental cross-sectional design using an online survey administrated at the end of Lesson 12. There was a total of 792 students who took part in this study. Ethics approval from the researched polytechnic's Institutional Review Board was obtained prior to the start of this current study. Students were informed by the lecturers as well as through the online consent form that their responses would be treated with confidentiality and they could withdraw from the study at any time during or after the research period. Most importantly, it was communicated to the students that their responses would not contribute to any of the assessment components stipulated for the module. Student generally took appropriately 15 minutes to complete the survey.

Instrument

The survey comprised two main sections, one section examined the demographic profile of the respondents while the other section addressed the aforementioned constructs of the research model. To measure learners' PEU and PU towards the use of the e-portfolio, the relevant items from TAM were adapted and modified to suit the local context (Davis, 1989). The items for the PLP construct were crafted with reference to the Assessment of the Teaching-Learning Process scale used by Cardelle-Elawar (2011) in his study on the relation of teaching and learning to students' satisfaction to learning. In addition, the items in the PVL were modified from the selected value/usefulness subscale of the Intrinsic Motivation Inventory from Deci (1991) to assess the perceived value of learning of learners throughout these three lessons, i.e. Lesson 10 to 12. All scale items were rated based on a five-point Likert scale represented as follows: 1 – Strongly disagree; 2 – Disagree, 3 – Neither agree nor disagree; 4 – Agree and 5 – Strongly agree. In total, there were 23 items in this scale representing the different constructs.

Prior to the measurement of students' perception of PEU, PU, PLP and PVL, the survey instrument used must possess sufficiently strong psychometric quality. First and foremost, the scale items were checked by two researchers (who also facilitated the described module) for face and content validity. Next, the internal consistency of the items in the scale were examined using Cronbach Alpha using SPSS statistical software version 24.0. It was found to be .97, exceeding the common threshold of .70 (Hair, Black, Babin, Anderson, & Tatham, 1998) which indicated high internal consistency for the items. The item-total correlation has values ranging from .62 to .83, above the minimum cut-off value of .3 as proposed by Cristobal, Flavián, and Guinalíu (2007). High internal consistency within the items in each factor was demonstrated by the Cronbach alpha values of .94, .94, .96 and .98 in the PLP, PVL, PEU and PU factors respectively.

Result analysis

The descriptive statistics for all the survey items were obtained as reflected in Table 1 below. The breakdown for the items in the different factors are as such: Item 1, 2, 9, 10, 11 and 12 are in the PLP factor; item 3 to 8 are in the PVL factor; item 13 to 18 are in PEU factor and item 19 to 23 are in the PU factor. All items in the scale garnered above average mean rating (above 3) in a 5-point scale survey. In particular, the mean for item 9, 10 and 12 were high ((M = 4.07, 4.05 and 4.13 respectively). On the contrary, the mean rating for items in the PEU and PU factor were relatively lower. Specifically, the three items with the lowest mean ratings were Item 16, 19 and 20 with (M = 3.31, 3.29 and 3.30 respectively). On the whole, the standard deviations of the items in the PLP and PVL factors were generally lower than the standard deviations of the items in PEU and PU factors, suggesting that the perception of learners in ease of use and usefulness of portfolio were more diverse than their perceived process and value of learning. On the other hand, skewness and kurtosis statistics are measurement of the normality of data. From the results shown in Table 2, the modulus value of skewness and kurtosis are all with one standard deviation from the mean, fulfilling the recommendation from Kline (2015).

Table 1. Descriptive statistics of survey items

Item	Mean	SD	Skewness	Kurtosis
1	3.94	.819	−.768	1.008
2	3.90	.869	−.803	.841
3	3.83	.936	−.802	.691
4	3.93	.863	−.855	1.111
5	3.98	.820	−.800	1.137
6	3.90	.894	−.821	.881
7	3.97	.825	−.804	1.103
8	3.99	.841	−.875	1.176
9	4.07	.817	−.762	.767
10	4.05	.788	−.782	1.120
11	4.02	.828	−.914	1.320
12	4.13	.777	−.965	1.756
13	3.51	1.166	−.574	−.413
14	3.36	1.194	−.402	−.663

15	3.42	1.135	−.498	−.393
16	3.31	1.206	−.353	−.743
17	3.36	1.210	−.420	−.673
18	3.39	1.229	−.510	−.604
19	3.29	1.228	−.405	−.708
20	3.30	1.197	−.410	−.608
21	3.34	1.183	−.479	−.532
22	3.33	1.195	−.475	−.547
23	3.34	1.209	−.484	−.609

As reflected in Table 2, high interrelations were found among all the four factors. In particular, the strongest correlation existed between the PEU and PU factors with r =.90, p <.001, followed by the relationship between PLP and PVL with with r =.89, p <.00. The means and standard deviations of the variables can also be found in Table 2. While these results provided preliminary insight into the relationships between the factors, the use of bivariate correlation measures do not furnish adequate information for making final conclusions to address the research questions. Multiple linear regression will be a more comprehensive approach to examine the interconnections of the different variables and the prediction of the dependent variable from the independent ones.

Table 2. Pearson bivariate correlation coefficients

	PVL	PLP	PEU	PU	Mean	SD
PVL	1				23.60	4.53
PLP	.89**	1			24.10	4.29
PEU	.48**	.47**	1		20.35	6.47
PU	.47**	.45**	.90**	1	16.58	5.74

Note. **p < .001 (1-tailed).

Multiple linear regression analysis was conducted to gain insight into the prediction of learners' perceived value of learning from the other three variables. The multiple regression model significantly predicted value of learning, $F(3, 788) = 1082.92$, $p < .001$, adj. $R^2 = .90$. All variables, except perceived ease of use, were positive and significant predictors of perceived value of learning. Table 3 indicates the summary status of the regression coefficients and standard errors of the variables.

Table 3. Regression coefficients and standard errors of variables in the scale

Variables	B	SE	β
(Constant)	.691	.410	
PLP	.903	.019	.855**
PEU	−.001	.026	−.002
PU	.070	.029	.089*

Note: B = Unstandardized regression coefficient; SE = Standard error of the coefficient; β = standardized coefficient; *p < .05; **p < .001

Discussion

From the analysis of descriptive statistics, it was evidenced that the learners have generally a good perceived process as well as perceived value of learning using e-portfolio for the cluster of lessons in the module. Learners were deemed to have *received timely feedback that assisted their learning*. They have also experienced *innovative learning and teaching approaches* to a large degree during the lessons. Most importantly, learners were able to *make connection to the concepts that they have learnt in the previous lessons*. On a side note, learners generally have relatively lower endorsement for the ease of use and usefulness for the e-portfolio implemented. For instance, it appeared that learners' interaction with the functions of Padlet can be further improved. Also, learners perceived that more can be done to enhance their work productivity and efficiency using Padlet.

Based on the correlational study, there existed significantly high positive inter-correlation between the different variables. This statistics showed that learner's perception of the ease of use of e-portfolio was highly associated with the usefulness perceived from using the e-portfolio. Learners might have perceived these two constructs to be strongly connected to each other. This is consistent with many other findings that the ease of use of technology adoption affects the usefulness that the technology can offer (Bhatiasevi, 2011; Davis, 1989; Mu-Yen Chen et al., 2012; Teo, 2009; Ursavaş, 2013). On the other hand, perceived learning process was also linked to perceived value of learning to a great extent. It was not a surprising result considering that the learning processes were deeply emphasised in PBL learning contexts. As such, learners derived value in their learning through explicit and direct involvement in their learning processes.

The multiple linear regression results indicated that a significant predictive model for studying perceived value of learning of learners via their perceived learning process, perceived ease of use and perceived useful of e-portfolio usage was established. In this present study, the theoretical model was able to explain 90% of the variability in various independent variables in relation to perceived value of learning. Not surprisingly, the perceived learning process variable was the most influential predictor of perceived value of learning as students were expected to be conscious of their learning processes such as being aware of own prior knowledge, conduct reflection and collaborate with their team members in a PBL learning setting. Although the perceived useful was a significant predictor of perceived value of learning, the effect was weak. This suggested that the impact of usefulness of e-portfolio in the perception of learners did little to influence their perceived value of learning. More scaffolding might be required for learners to assist them in using the e-portfolio productively and efficiently. While perceived ease of use emerged as an insignificant predictor for perceived value of learning for learners, it might be due to the earlier findings that they generally found Padlet to score lower in the area of flexibility. It also exhibited learners' feeling that the idea of working productively and efficiently with Padlet might not be appealing to them. Hence, the relative insignificance of the effect from the perceived ease of use variable supported the idea that there should be more focus on enhancing training and support for the use of Padlet for learners.

Implications for practice

The results of this study have practical implications for the module team of the described module, because it increases understanding of how an effective e-portfolio could be introduced in the module to enhance perceived process and value of learning and promote acceptance of the pedagogical tool through raising learners' perceived ease of use and usefulness. This study demonstrated that Padlet is a promising tool to be used in scaffolding students in their learning. On a positive note, it has also been verified that learners found Padlet to be relatively useful in their learning and they can track their processes of learning adeptly. For creating a more positive experience with the use of Padlet, the module team can provide both lecturers and learners with sufficient resources and instructions. In addition, training to use Padlet can be conducted earlier in the academic semester. As such, possible technical and pedagogical issues can be addressed in the earlier stage of learning to engender a better learning experience and in turn enhanced acceptance of the e-portfolio.

Limitations and future research

Firstly, the user acceptance of the technological aspect of the newly introduced Padlet tool was not fully investigated. As highlighted in the result findings, other variables could be added into the investigation of acceptance of the e-portfolio to generate a better overall learning experience for the learners. The technology acceptance model (TAM) could be examined in more detail in future research to explore users' belief variables (perceived ease of use and usefulness), affective variable (attitude to use) as well as behavioural variable (intention to use) (Davis, 1985). Secondly, while this study provided the perception of students towards Padlet as an effective pedagogical tool in promoting learning, it is also critical to focus on the perspectives of teachers towards the use of e-portfolio in facilitating learning and potentially examines the different ways in which Padlet could help in the area of formative or even summative assessment in terms of continuous assessment grading. Thirdly, this study is primarily a quantitative research study. Qualitative research, using focus group discussion approach could provide more insights in the specific ways students use Padlet in their learning as well as the challenges faced by individuals in adopting this tool. Interviews with the lecturers could also be arranged to understand the constraints faced in facilitating teams' discussion, sharing and presentation via Padlet. Indeed, the benefits of learning derived from the use of e-portfolio are more important than the fashionable implementation of the technological tool.

Conclusion

In sum, this preliminary study will contribute to the literature on the learners' perceived value of learning and perceived learning process using e-portfolio in a curriculum of a module. It furthers the discussion on subsequent use of the e-portfolio in all lessons as a mean of formative evaluation of students' learning. Most importantly, it will also allow the team responsible for the described module to consider the future curriculum, pedagogical, delivery and assessment direction of the module and any change, if necessary, that needs to be effected.

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An innovative approach on using Cognitive Apprenticeship for skills acquisition in learning Computer Programming

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Abstract

Cognitive Apprenticeship (CA) is an instructional model that builds on the apprenticeship model to support learning in the cognitive domain. It aims to make the thinking of experts 'visible' to the novices so that they can make sense of the learning. Two Lessons were designed using CA to teach the concepts of functions and loops in C programming to innovatively support the three stages of skills acquisition (SA). The aim of this paper is two-fold, firstly it seeks to examine the learners' experiences when they engage with the content of functions and loops underscored by the distinct pedagogy of CA. Secondly, the practitioner's view on the theoretical link between CA and SA is discussed. Qualitative methods and specifically content analysis was used to analyse data obtained from reflection journals (RJ) administered to 59 learners from various diploma programmes. Data was analysed using the three levels of coding, namely, open-, axial- and selective- coding to produce themes. The two themes that surfaced from the analysis were positive CA experience and avenue for refinement. An important finding within the theme of positive CA experience is the dominance of the four CA dimensions encompassing the CA methods of modelling, articulation and coaching. Indeed these methods attest to the essence of the difference between CA and traditional lecture-based learning. Moreover, 80% of the learners found that the distinctive CA pedagogy adopted for teaching concepts of functions and loops helped them learn better. There was evidence in support of the cognitive, associative and autonomous stages of SA, indeed, showing the link between CA and SA. The avenues for refinement in the CA lessons' design that surfaced was found to be the duration of the sessions as well as incorporation of differentiated instructions to support the diverse profile of learners.

Keywords: *Cognitive Apprenticeship, Computer Programming, Skills Acquisition Theory, Qualitative Analysis*

Introduction

Learning programming often involves learning a set of skills instead of a single skill. Teaching programming is a complex process. Many studies have suggested that programming is often perceived as difficult by novice learners (Gomes and Mendes, 2007). Due to the universal problem of high failure rates for introductory programming modules, many researchers have proposed tools and methodology to enhance the learning experiences of learners when they learn programming (Ma, Ferguson, Roper and Wood, 2011). One of the difficulties faced in learning programming by novice learners as suggested by past studies is the use of inappropriate teaching methods that leverage on static teaching materials like projected presentations, diagrams, text etc. to teach dynamic programming concepts (Lahtinen, Ala-Mutka and Järvinen, 2005). This results in a lack of hands-on practice in writing programs, as well as decreased motivation and confidence in programming among the learners. Since programming concepts involve a high level of abstraction, learners often cannot 'see' what is happening 'in the computer' when a program is being executed (Ma et.al, 2011). CA is a theory of the process in which a master of a skill teaches that skill to his apprentice with an emphasis on cognitive rather than physical skills (Edmonson, 2007; Collins, Brown, & Newman, 1987; Brown, Collins, Duguid, 1989). In CA, the tacit processes are deliberately made visible, abstract tasks can be made to make sense since it is possible to see them in the context of situations, and curriculum concepts can be introduced by varying the diversity and complexity gradually so as to enable transfer of learning to real-world applications (Collins, Brown, & Holum, 1991). CA has been proven to be an effective instructional strategy to teach abstract and complex skills in mathematics, science and computer programming (Fernandez, 2014). This researcher advocates an instructional strategy for face-to-face, blended, as well as online learning environments. In the literature, there is a lack of evidence on the use of CA for teaching C language concepts on functions and loops. This study intends to fill this gap.

Many authors have described that CA supports skills acquisition (Anderson, 1983; Fitts & Posner, 1967). Skills Acquisition theory explains the three stages of skills acquisition as: cognitive stage - the learner acquires declarative knowledge about the skills by passive observation without even trying to use it, associative stage- the learner interprets the mistakes and makes connections within the critical elements by turning the declarative knowledge gained in the first stage to procedural knowledge and autonomous stage - the final stage in which the skills are honed and perfected through practice in situated contexts (VanPatten and Williams, 2014).

The CA learning environment consists of four dimensions: content, method, sequence, and sociology (Collins et. al., 1991). In the introductory course on C programming, two lessons were designed using CA to teach the concepts of functions and loops and data was collected from 59 learners' reflection journals. The lesson on functions preceded the lesson on loops. The aim of this paper is to understand how functions and loops can be taught using CA instructional model. Specifically this paper seeks to answer the following research questions:

1. How do learners experience the learning of functions and loops in a CA learning environment?

2. What is the link between CA and SA when teaching functions and loops?

In the following section, the principles of designing these lessons for the CA environments are detailed. Each dimension is elaborated with examples.

Cognitive Apprenticeship in teaching functions and loops

The four dimensions of the CA learning environment are in Figure 1:

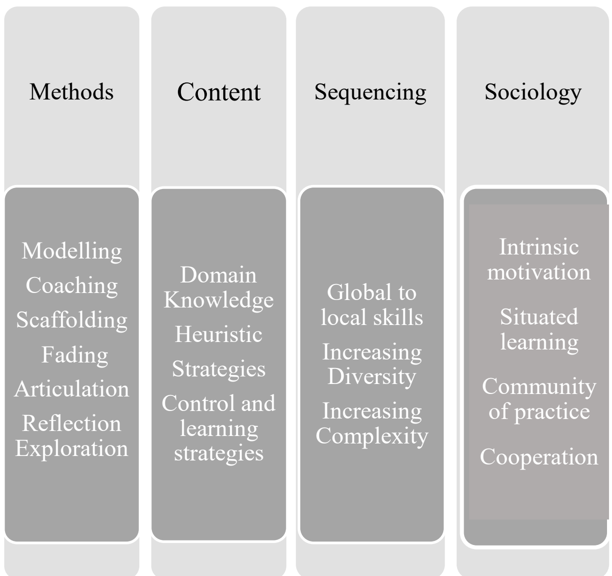

Figure 1: CA learning environment

CONTENT: types of knowledge required for expertise

a. Domain knowledge: Lecturer shares the specific concepts, facts, and procedures on functions and loops. Lecturer shares the difference between user-defined and library functions, C syntax for functions comprising of the 3 element structure. The different types of repetition structures and ITLU (Initialization, Terminal condition, Loop boy and update variable) elements in the different loops are shared.
b. Heuristic strategies: Lecturer shares the steps involved in writing the 3-element structure of functions: function prototype, function definition and function call. In context of loops, lecturer shares the C syntax for writing while, do-while and 'for' loop as well as the importance of ITLU elements in each loop.
c. Control and learning strategies: Learners troubleshoot their program for successful execution, they look for the syntax errors, missing steps in writing the functions and loops.

METHOD: ways to promote the development of expertise

a. Modeling: Lecturer models typing and executing a complete C code in Microsoft Visual Studio C compiler at the same time makes the thinking visible by verbalizing in a systematic step-by-step fashion so that the learners can observe. Lecturer demonstrates the program flow using the debugging function in C compiler to allow the learners to 'see' what happens 'in the computer' when a program is executed.
b. Coaching: Lecturer observes and facilitates the learners to perform small tasks by providing corrective feedback as learners attempt the tasks on their own.
c. Scaffolding: Worksheet scaffolding is provided to learners to help them solve programming exercises.
d. Fading: Lecturer support reduces gradually as learners gain confidence in solving programming exercises and are able to perform the task on his own.
e. Articulation: At the end of each exercise, learners are invited to pair-up, 'think aloud' by articulating and reflecting on their work including the challenges faced
f. Reflection: learners compare their work with their peers and lecturer encourages peer teaching
g. Exploration: Lecturer invites the learners to solve additional programming exercises individually.

SEQUENCING: keys to ordering learning activities

a. Global before local skills: Learners are shown examples of functions used in microcontroller applications to help them construct a conceptual model and make sense of the whole task before executing the parts, this in a way improves their ability to monitor their progress and develop self-correcting skills as they are aware of the end product. In the context of loops, learners are shown the candy crush game and probed to think on what causes the game to end.

b. Increasing complexity: Programming exercises on functions and loops with gradually increasing difficulty are introduced. This helps to equip learners, in gradual sequential manner, with the concepts needed for expert performance. Scaffolding in the form of worksheet and lecturer's coaching helps learners to handle the complex set of activities needed to accomplish the given task.
e.g. *Function#1.Write a complete C-code using a user-defined function that* ***adds two decimal numbers entered by the user*** *and returns the sum with two decimal place accuracy.*
Function#2. Write a complete C-code using a user-defined function that calculates and returns the ***area of a circle*** *based on the* ***radius input by the user****.*
Fucntion#3. Write a C user-defined function that checks whether an integer entered by the user is even or odd and ***returns 1 if it is even and 0 if it is odd****. Call the function and print the message "Number entered is even" if it is even number and "Number entered is odd" if it is odd number.*

c. Increasing diversity: Different programming exercises are given to allow learners to practice writing functions and loops in a variety of situations to emphasize broad application..
e.g. *Function#1.Write a C user-defined function to* ***compute the cube of an integer number*** *and return the result.*
Function#2.Write a C user-defined function that ***computes the product of two decimal numbers*** *and returns the result.*
Function#3.Write a C user-defined function that ***prints a line of asterix.***

SOCIOLOGY: social characteristics of learning environments

a. Situated learning: Learners learn in the context of working on realistic tasks like calculating distance between two points using functions, or calculating sum of natural numbers using loops as they would need to work on these contexts later in their education.

b. Community of practice: Lecturer encourages a learning environment through sharing of experiences in which learners actively communicate with each other about the skills developed, discuss meaningful ways to solve the programming exercises. This leads to developing a sense of ownership and mutual dependence among the learners.

c. Intrinsic motivation: Lecturer creates a learning environment in which learners perform tasks because they are intrinsically related to an interesting or coherent goal by giving them meaningful programming exercise.
e.g.*Write a C program to calculate the area of any number of rectangles input by the user. Program should ask the user to enter the length of the sides of the rectangle.*

d. Cooperation: Learners are encouraged to work together. They are paired and asked to share their thinking process as well as the program flow with each other. They are encouraged to question each other's inferences.

Methodology

In this section, I discuss the analysis of qualitative data obtained from 59 learners' RJs, to find out how learners experience the learning of functions and loops in a CA learning environment. Several authors suggest that codes are efficient and help to organise data through its labelling and retrieving access (Miles & Huberman, 1994; Neuman, 2003). One of the well-known proposals in analysing qualitative data is for the researcher to identify and locate patterns and associations within the participants' words and actions (Neuman, 2003), but at the same time remain in close contact with the construction of reality as seen from the participants' perspective. The three levels of analysis as proposed by Neuman (2003), namely, open-, axial- and selective-coding, was adopted for this study.

A total of 50 descriptive codes were obtained from open coding, , in which all lines of the RJ were read and given a category label. These codes are then examined and organized into clusters of related categories called axial codes and reflect the different aspects of the CA model. The open codes were re-organised into 14 different aspects of cognitive apprenticeship learning environment. The diagrammatic representation of how the open-, axial-codes and themes were derived is shown in Table 1. Two major themes were identified.

Excerpts from RJ are used to illustrate the coding process as below:

Example A: S*ince we see a similar programme first before starting to do the programme we have an idea about it , so it became much easier. And it also helped me to learn through practise. If we learn something through practise it is said that we wont forget it. So the different way of teaching was a good experience. Since we do more than five problems it helps us to get experience , we are unknowingly practising the programmes. So I felt this as a good experience..*

The open codes assigned are: 'see example first' , 'practice' and 'good experience'. At axial coding level, the open codes are grouped into a broader category code called 'Modelling'. Lastly, in selective coding, this code goes into a theme called 'positive CA experience'.

Example B: *The way of learning that was followed in the lesson 5 and 6 was very interesting as it was the* *interactive session. It provide many opportunity to interact with each other which helps gradually to have more clear views on the portions. The interactive section will help to increase the level of knowledge. It was very help full. I am much more oblige to you to clear all my doubts during the class.*

At the opening coding level, this was assigned the codes 'interesting', 'interactive', 'clear doubts' and ' increase the level of knowledge'. At axial coding level, it is grouped into a broader category code called 'articulation'. Lastly, in selective coding, this code goes into a theme called 'positive CA experience'.

Example C: *Honestly, its fine its just that without the breaks given i feel like i can't cope as theres too much information to digest within the time limit. It gets harder and harder as the weeks approaches.*

At the opening coding level, this was assigned the codes 'without breaks' and ' too much to digest'. At axial coding level, it is grouped into a broader category code called 'duration of session'. Lastly, in selective coding, this code goes into a theme called 'Avenue for refinement'.

First Level	Second Level	Third Level
• pairing • smaller number of people • discuss/opportunity to interact • think aloud	Articulation	Positive CA experience
• lecturer explains/ examples • lecturer solves • see example first	Modelling	Positive CA experience
• hunger • Long sessions • No rest • Need brain break • timing	Duration of session	Avenue for refinement
• confusing • hard to understand • tired and bored • defective • lagging behind	lack of differentiated instruction	Avenue for refinement

Table 1: Coding for qualitative analysis

Out of the 59 student responses on RJ, 47 responses showed that the learning experience was found to be positive while 12 responses showed that there is avenue for refinement to the learning environment.

Positive learning experience consists of learners reporting the following: sessions were interesting, pairing allowed them to discuss and articulate thoughts, demonstration by lecturer helped them to grasp the concepts better, CA provided more opportunity for hands-on practice and allowed greater lecturer support during application of concepts. Out of the 12 responses which showed that there is avenue for refinement to the learning experience, it was found that all the first level codes pointed to either ‘duration of session’ or ‘lack of differentiated instructions’. The code ‘duration of session’ was used as the learners found the CA sessions to be long with minimal breaks. The code ‘lack of differentiated instructions’ was used as some learners lagged behind and found it difficult to cope.

In the following section, it is discussed how the learners develop the skills in programming concepts of functions and loops during the lessons delivered using CA pedagogy. The link between CA and SA is described in more details in the cognitive, associative and autonomous stages of SA.

Practitioner’s view on the possible connection between Cognitive Apprenticeship and Skills Acquisition

Figure 2 shows how the three stages of SA are supported by the CA instructional strategy incorporating the different elements of CA. The link between CA and SA is described in more details in the cognitive, associative and autonomous stages of SA.

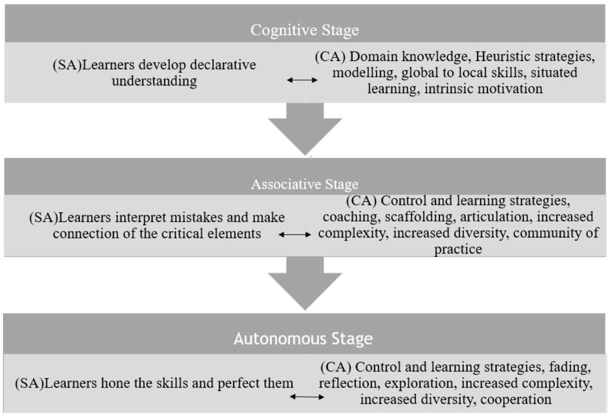

Figure 2. Link between CA and SA

Stage 1: Cognitive Stage of SA

For functions and loops, when the lecturer disseminates domain knowledge by modelling the basic structure of functions and loops, syntax of C codes and steps involved in writing the program by typing and executing a complete C code, he employs the heuristic strategies which in turn help the learners develop a declarative understanding of the concepts. In this stage, the lecturer shows real world application examples for situated learning so that the learners are able to develop a conceptual model which help them to relate global skills to local skills. Thus, at this stage the learners are motivated to solve the examples seeing the lecturer demonstrate.

Stage 2: Associative Stage of SA

Learners develop their procedural knowledge in this stage by interpreting mistakes and making connection of the critical elements. During coaching by lecturer, which involves getting learners to troubleshoot and eliminate their mistakes, learners will be able to make associations between the concepts e.g. Structure of functions, four elements of loops. Worksheet used as scaffolding helps the learners to solve the programming exercises that vary in complexity and diversity. Pairing and sharing provides avenue for articulation after each exercise to support learning from own mistakes as well as through mutual collaboration that promotes cooperation.

Stage 3: Autonomous Stage of SA

Learners hone their skills and perfect them as they solve the application exercises which pose increasing diversity and increasing complexity. They are able to perform the tasks on their own without lecturer support. At this stage the lecturer support fades. During this process, learners explore different application exercises on their own by comparing their work with their peers'. Reflection and Exploration phases in CA model of instruction support this stage. This stage encourages sharing of professional practice in the respective domains through cooperation.

Table2 shows the diagrammatic representation of how the themes of 'positive CA experience' were linked to the three different stages of SA.

First Level	Second Level	Third Level
• lecturer explains/ examples • lecturer solves • see example first	Modelling	Positive CA experience (Cognitive Stage)
• pairing • smaller number of people • discuss/opportunity to interact • think aloud	Articulation	Positive CA experience (Associative Stage)
• troubleshooting • self correction • less errors • self reliant	Fading	Positive CA experience (Autonomous Stage)

Table 2: Coding for qualitative analysis in SA

Thus it can be concluded that theoretically, CA model of instruction incorporating the four different dimensions has a strong link to the three stages of skills acquisition. As the lecturer progresses through the lesson using CA instructional model, he/she inherently supports the skills acquisition of the learner through the different stages of cognitive, autonomous and associative in grasping the concepts of functions and loops.

Conclusion:

In examining how students experience the learning of functions and loops in a CA learning environment, qualitative analysis was carried out on 59 students' RJ. The two themes emanated were positive CA experience and avenue for refinement. Furthermore, the different dimensions of CA instructional model like methods, content, sociology and sequencing were evident in the learners' reporting through reflection journals. An important finding within the theme of positive CA experience is the dominance of the four CA dimensions encompassing the CA methods of modelling, articulation and coaching. Certainly these methods accentuate the difference between CA and traditional lecture-based learning. This affirms the suitability of CA for teaching and learning programming concepts of functions and loops. Moreover, 80% of the learners found that the distinctive CA pedagogy adopted for teaching concepts of functions and loops helped them learn better There was evidence in support of the cognitive, associative and autonomous stages of SA, indeed, showing the link between CA and SA. The avenues for refinement in the CA lessons' design that surfaced was found to be the duration of the sessions as well as incorporation of differentiated instructions to support the diverse profile of learners. We note that the study involves a limited sample size and would caution the generalizability of the results. However, the research provides sufficient evidence for further in-depth explorations.

Further studies may include studying the assessment results for the learners on components related to functions and loops to gain more useful insights on the success of CA learning environments in learning programming concepts like functions and loops.

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FROM GENERAL TO ENGINEER'S ENGLISH: INTRODUCING ENGLISH TECHNICAL WRITING TEST

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Abstract

This study began when the conversation took place between teachers from general education department and engineering department at the National Institute of Technology, Ibaraki College (hereinafter referred to as "Ibaraki Kosen"). The topic was what they could do to bridge the gap between English taught as a language and technical English with terms specially used in a specific area of engineering. The English Technical Writing Test (hereinafter referred to as "ETWT") is a nationally recognized certificate in Japan, managed by the Japan Society for Technical Communication (JSTC) since 1981. In 1992, ETWT became authorized by the Ministry of Education, Culture, Sports, Science and Technology-Japan (MEXT) and now it is widely taken by students at technical high schools and colleges, professionals and researchers in science and technology. ETWT has four different grades according to the level of knowledge; Level 4 is for those with technical knowledge in English at technical high school, Level 3 for those at a lower grade in college, Level 2 for working engineers, Level 1 for professionals. With the support of other English teachers, the author decided to give the practice ETWT for Level 4 to most of 1st and 3rd year students at Ibaraki Kosen. The results show that 48% of 1st year students and 68% of 3rd year students had a passing score. Also the feedback from the students were positive. Many of them admitted that English was not their favorite subject, yet the questions and terms on ETWT were familiar to them since some of the subjects such as Physics, Chemistry and Global Life Science were taught in English. Considering this positive outcome of ETWT, a change was made for the 2nd and 3rd year English classes for the upcoming academic year. In addition to conventional English textbooks, the students would have a new textbook which had a strong emphasis on technical terms in science and engineering. Further research is required to figure out the effect of this contents change over students' academic achievement.

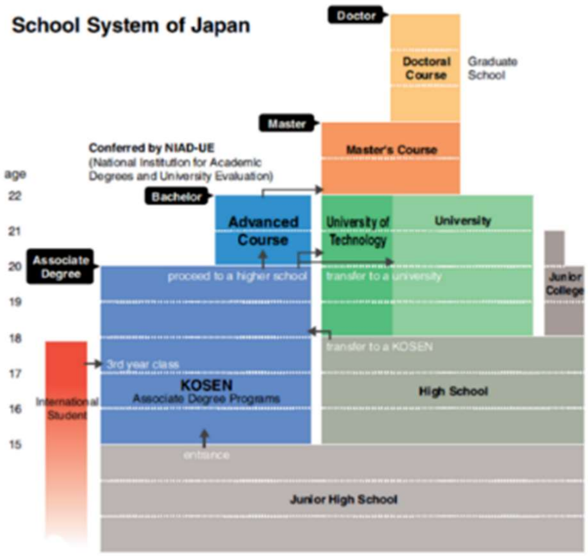
Keywords: *English for Specific Purposes, higher education, technical English, ETWT, National Institute of Technology (Kosen)*

Introduction

This study began when the conversation took place between two teachers at Ibaraki Kosen; one from a general education department and the other an engineering. The topic was what they could do to bridge the gap between English taught as a foreign language and English taught with terms specially used in a specific area of engineering. The engineering teacher expressed his concern that his students did not learn enough technical terms at lower grades; on the other hand, the general education teacher wondered that teachers at upper grades could give their students enough instruction on language and grammar. They never reached any conclusion at that point, yet one possible solution was to introduce "English Technical Writing Test (ETWT)" into English classes in the 2nd or 3rd year English curriculum. The author gave the sample ETWT Level 4 to her students in the 1st and the 3rd year for data collection and analysis, then asked casually what they thought of the test.

About Kosen

"Kosen" is an abbreviation of Japanese word meaning "National Institute of Technology". As of February 2020, there were 57 Kosen schools in Japan: 51 state, 3 public and 3 private. Kosen system was founded in 1962. Kosen schools accept junior high school graduates and offer 5-year education. After graduating from Kosen schools, some start working; others transfer to four-year universities. Kosen also offers two-year advanced course. After the advanced course, students can either start working or continue their study at a graduate level. The following chart illustrates the school system of Japan.



(Chart taken from
http://www.ibaraki-ct.ac.jp/?english=about-nitic#ch05)

About English Technical Writing Test (ETWT)

The English Technical Writing Test (ETWT) is a nationally recognized certificate in Japan, managed by the Japan Society for Technical Communication (JSTC) since 1981. In 1992, ETWT became authorized by the Ministry of Education, Culture, Sports, Science and Technology-Japan (MEXT) and now it is widely taken by students at technical high schools and colleges, professionals and researchers in science and technology. ETWT has four different grades according to the level of knowledge; Level 4 is for those with technical knowledge in English at technical high school, Level 3 for those at a lower grade in college, Level 2 for working engineers, Level 1 for professionals.

As of April 2021, ETWT has changed its grading system; new Level 3 is equivalent to old Level 4, new Level 2 is to old Level 3, new Level 1 is to old Level pre-2, and new Level Pre-Professional is to old Level 2, and new Level Professional is to old Level 1. In this paper, I use the old grading system.

Among 57 Kosen schools, Kisarazu in Chiba Prefecture and Suzuka in Mie Prefecture received the ETWT school award: Kisarazu for the number of students who took the test (N=249) and Suzuka, the 3rd time recipient, for their ongoing contribution to the ETWT. Tomakomai Kosen in Hokkaido hosted ETWT for 10 years, and the study of Ohashi and Matsuo (2004) archived the test results from 1994 to 2004.

Past Research on Kosen and ETWT, Development of English Teaching Materials

Many students entering Kosen understand English is necessary for their future career, yet they believe it is not taught enough, compared to other college-bound high schools (Yano, et. al, 2018). The data of 3,400 answers from 13 Kosen schools examined the effectiveness of education at Kosen schools and how it influenced graduates' career decisions. One of the major findings was that the lack of English language ability had significant correlation with Kosen graduates' current job description. As mentioned in Kosen's model core curriculum, English language education is focused on to enable students to give presentation in English regarding their specialization. Here the question is that how we English teachers teach those who already hesitate to learn.

Shioya at Numazu Kosen studied motivation of Kosen students. In his 2005 paper, he gave his students quizzes which contained technical terms; by doing so, his students could find motivation to study English for their preparation for upper grades and have a sense of achievement. In 2008, he introduced ETWT to his students as a part of their extrinsic motivation that getting a certificate would look "good on their CV." In 2010, more freshmen and 2nd year students at Numazu Kosen took ETWT for transferring units, which could be explained as the result of extrinsic motivation. Baba (1996) also mentioned qualification tendency of ETWT, it would have an advantage in employment after graduation. Aoyama, et al. (2004) also found that ETWT suited the academic interest of Kosen students, since it contained many scientific and technical words. Fujii (2017) related student motivation to technical English; students' interest was stronger if the topics were closely related to their majors.

For the last 3 decades, English teachers at Kosen schools struggled to close the gap between general English classes and upper grade classes taught by teachers of specialized courses. English teachers at Kosen schools have been searching for an effective tool to teach English. Toya (2000) conducted the teachers survey, asking for frank opinions from Kosen English teachers. The data from 53 schools and 305 teachers showed they acknowledged the importance of closing the gap between general and specialized courses / subjects. Takahashi (1988) at Nara Kosen pointed out that ETWT would be useful preparing students for the upper grade courses since lower grade English classes did not deal with technical terms. Teaching with ETWT materials would assist English teachers with their classes. Five years after his initial research, Takahashi and his colleagues edited a textbook with the aim of preparing for ETWT. The textbook contained sample questions of ETWT, about 600 idioms and sentences, and about 2,000 technical terms. In 2000, a group of teachers from COCET (The Council of College Teachers) started a project which focused on the English curriculum at Kosen campuses. Their final products were a word book "COCET 3300" and a self-study website called "Kosen English Town." COCET 3300 contained science and engineering words, selected from other sources such as the vocabulary list by University of Hokkaido and the word book by Voice of America (Aoyama et al., 2004).

Data collection

With the support of other English teachers, the author gave the Level 4 ETWT to the 1st and the 3rd year students at Ibaraki Kosen. The test used for this data collection was taken from the JSTC website for public use. The Level 4 ETWT was given to the students in the mid-November 2019, right after the Fall semester midterm examination week. After receiving the midterm results during the regular English class, students were told that their participation and results did not affect their grades for the regular English class. When proctored properly, it would take 60 minutes for the Level 4 ETWT, yet due to time constrains, students had at most 40 minutes to work on the Level 4 ETWT for this data collection. The number of students participated in this data collection were 199 for the 1st year and 185 for the 3rd year students. After taking ETWT, the author observed each classroom for student reaction, listening to their conversation and asking them what they thought of ETWT.

Results and Discussion

The Level 4 ETWT consisted of 7 sections, and the passing score is 120 out of 200, which is 60% of the total score. The results show that 48% of the 1st year students and 68% of the 3rd year passed the Level 4 ETWT. Although they did not have any preparation for this test, the highest score was 184 for the 1st year students and 198 for the 3rd year. Surprisingly the feedback from the students were positive. Many of them admitted that English was not their preferred subject, yet the questions and terms on ETWT were familiar to them since some of the subjects such as Physics, Chemistry and Global Life Science had already been taught in English. One student said, “Words were a bit difficult, yet the grammar was not that difficult compared to our reading classes. I loved that some of the test contents were familiar to me regarding my specialization.”

Conclusions

ETWT and course materials containing technical terms would be useful for Kosen students to keep their motivation for learning English. Considering the positive outcome of ETWT on both scores and students’ feedback, a change has already made for the 2nd and 3rd year English classes for the upcoming academic year after the data collection (2020-2021). In addition to conventional English textbooks, the students have a new textbook with a strong emphasis on technical terms in science and engineering. Also encouraging students to take ETWT on fall is being considered on the management level on campus. As of August 2021, a group of student hosted a free information session on ETWT, and they are planning to take ETWT on campus. This study did open the door of opportunity to our students in terms of preparation for the future career.

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Project-Based Learning as a Pedagogical Approach for Financial Technology Education

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Abstract

Financial technology (FinTech) is rapidly changing traditional financial businesses via enablers such as blockchain and artificial intelligence. FinTech professionals need to possess creativity and problem-solving skills as they constantly face a host of technological, legal and regulatory challenges. On the surface, project-based learning (PjBL) provides an ideal learning environment to acquire those skills. This research aimed to examine if learning evaluation affirmed implementation of PjBL as a positive pedagogical approach for tertiary-level FinTech courses. Research applied a nested integrative mixed-method approach in which anonymized questionnaires were used to collect both quantitative and qualitative data using quantitative Likert-scale surveys and open-ended survey questions. Results validate the use of PjBL as a positive pedagogical approach for FinTech courses, and provide findings useful for application of PjBL to FinTech education practitioners.

Keywords: *Project-Based Learning; Pedagogy; Higher Education; Finance; Technology; FinTech; Mixed Method.*

Introduction

The origin of PjBL can be traced back to more than a hundred years ago to the work of educator and philosopher John Dewey, who reasoned that learners would develop personal investment in the material if they engage in authentic, purposeful assignments and problems that emulate what professionals perform in everyday situations (Krajcik & Blumenfeld, 2006). As a learner-centric pedagogy, PjBL involves a dynamic classroom approach where learners acquire deep knowledge of a discipline through active exploration of real-world challenges centred around project work.

With the fast-changing pace of technology and the exciting innovations brought about by Industrial Revolution 4.0 in the financial landscape, educational providers and financial institutions around the world seek to keep up with changes in financial technology (FinTech) to prepare learners and employees for the evolving working world.

This research examined PjBL as a pedagogical approach for FinTech courses. The research contribution of this paper is to provide a thorough examination of the employment of PjBL pedagogical approach to FinTech courses. As of the time of this research, to our best knowledge, there was only one study (Li et. al., 2020) investigating PjBL implementation in FinTech courses. While Li et. al. (2020) showed promise in PjBL implementation, it was a limited scope qualitative study with a small number of participants. The authors of Li et. al. (2020) acknowledged that "the sample size in this pilot study was relatively small… opinions and feedback provided by students in the interviews [were] inherently biased and [might] not be generalized." Results of Li et. al. (2020) indicated PjBL as a positive pedagogical approach to FinTech courses.

The findings of this study will be useful for teaching practitioners delivering courses in FinTech domains, both within educational providers and financial institutions. In addition, non-domain specific technology courses that may be best taught through the PjBL approach can also benefit from the practical insights of this paper.

Literature Review

The primary merits of PjBL lie in enhancing motivation and fostering cognitive enhancement by organising learning around projects. Many studies have affirmed the increased motivation levels and improved learning abilities when learners engage in PjBL activities. Hung et al. (2012) conducted a study on project-based digital storytelling for a group of elementary school learners where they found the approach enhanced the learning motivation, attitude, problem-solving ability and learning successes of the learners. Likewise, Chiang and Lee (2016) saw a positive effect of PjBL on learning motivation when they conducted a study on vocational high school learners majoring in food and beverage. The result encourages the vocational high school teachers to adopt PjBL in their teaching approach as their learners are more likely to find joy and motivation in PjBL activities than in traditional teacher-centric instruction. PjBL also has a positive impact on learners struggling with their learning as can be seen in the study by Filippatou and Kaldi (2010) that examined the effectiveness of PjBL on primary school pupils with learning difficulties. In addition to better academic performance, the learners with learning difficulties also improved their attitude towards group work, their acceptance within the group and their participation in the learning process.

FinTech, or technology-enabled innovation in financial services, is a combination of the terms "financial" and "technology". It is more suitably defined as "technologically enabled financial innovation that could result in new business models, applications, processes, or products with an associated material effect on financial markets and institutions and the provision of financial services" by Financial Stability Board (2017).

There are limited studies on FinTech education. Sung et. al. (2019) justified a clear market need for FinTech education. Kursh and Gold (2016), Jamil and Seman (2019), and Marwan and Saeed (2020) found promise in FinTech education, and supported the development of FinTech curriculum as an enabler for career advancement for business and technology students. Li et. al. (2020) proposed a course development framework incorporating PjBL, learner-centered design, backward design, and universal design for learning, and found value in PjBL implementation. However, Li et. al. (2020) was a limited scope interview-based qualitative analysis with a sample size of only four participants, which might introduce biasness to the results of the study.

As research had indicated, FinTech education holds promise. The limited studies done on FinTech education, and, in particular, the application of PjBL pedagogical approach to FinTech courses, lent value to the discussions and results of this study.

Methodology

Course background

As part of a revamp of the curriculum in a banking and finance major, a new FinTech course was introduced as a gradable elective in an institute of higher learning in Singapore. This course is offered in Year 2 semester 2, as part of the 3-year Diploma of Banking and Finance. The course covered an overview of the development of FinTech and its role in disrupting the financial services industry. Learners learnt how banking and finance services are transformed by FinTech in alternative funding, automated investment advice and InsurTech. Learners also gained awareness of the technology enablers, such as big data, blockchain, application program interface (APIs) and machine learning, that are fuelling the growth of FinTech. This was a FinTech course that introduced broad-based FinTech concepts.

For the 15-week Fall 2019 semester, teaching was structured in two-hour sessions twice per week: (i) The first lesson of the week focused on learners' understanding of broad-based FinTech concepts. The lesson covered topical flipped classroom-format curated reading, concept-based learning activities and critical question and answer review of concepts. These were to ensure that learners grasp requisite foundational FinTech knowledge as they undertook their respective project assessments. (ii) The second lesson of the week focused on project status review and project scaffolding to ensure that the progress statuses were on track with project submission milestones. Learners engaged in applied project discussions and work. From time-to-time, learners presented their findings for critique and iterative improvements.

Assessments were group-based, with both group and individual assessment rubrics. Learners were assessed through one FinTech consultancy group project comprising of 4-6 members per group. The group project was split into three milestones of weightages 10%, 30% and 45% respectively. The remaining 15% pertained to scores for class participation. Learners submitted and presented their findings at the end of each milestone. Submission of findings were cumulative, which meant that the final milestone submission, for instance, would include the deliverables for the final milestone, and the iteratively improved deliverables of the first and second milestones, combined into one completed FinTech project.

The FinTech group project simulated an actual industry consulting FinTech client project. Using PjBL techniques, learners, in groups, selected an industry client, and made practical and innovative proposals, using FinTech tools and technology enablers, to reshape the chosen client's market positioning and product offerings. Learners would have to assess the sensibility and desirability, business viability and technological feasibility of the FinTech solutions, and propose pragmatic solutions that could impact the near-and-long term future of the client. Infusion of PjBL followed the gold standard PjBL project design and teaching practices as proposed by the Buck Institute of Education (Larmer, Mergendoller & Boss, 2015).

Pre-post course semi-closed survey

This study was conducted on the aforementioned course in an institute of higher learning based in Singapore in the fall semester of 2019. The learners had little or no experience in PjBL-type education format. 50 learners enrolled in the course. This study achieved a response rate of 74%, with 37 anonymized learners of the pertinent FinTech course of 50 learners participating in the study, which helped add stability to the results.

Anonymized online surveys were administered pre- and post-course to determine pre-course expectations and post-course feedbacks of the utilization of PjBL to learn FinTech concepts. Anonymity, where expressed responses are not identified as being from specific members of the panel, helps overcome issues of potential research biasness and group think (Browne et al., 2002) (Somerville, 2008).

In total, 17 close-ended 5-point scale Likert scale-type quantitative questions were administered in two separate pre-post course surveys. As both pre-post quantitative surveys utilized different Likert scale numbers, the results were standardized to the 0-1 range for comparability purposes. Refer to Tables 1 and 2 for quantitative survey questions.

The qualitative questions included open-ended questions as follows: (i) *Do you agree that PjBL is an appropriate format to deliver the FinTech course. Please provide reasons, if any;* (ii) *Describe three key takeaways* *from the course;* (iii) *Please provide any other thoughts you may have regarding PjBL implementation of the FinTech course.*

Results and Discussion

Quantitative analyses of pre-post course surveys – Learners' views on learning expectation and experience

Results from the post-course survey can be gleaned from Table 1. The mean and standard deviation (SD) of rating scores were computed, with 1 being the best, and 0 being the worst.

Category	Indicator	Item	Mean	SD
Post course ratings	Course rating	Overall course rating	0.7100	0.2350
	Teaching	Lecturer taught lectures well and explained the course content clearly	0.8000	0.1710
	Assessment	Assessment components and criteria were useful to assess the learning outcomes	0.7500	0.2180
	Learning outcomes	Learning outcomes were clearly stated and explained to learners	0.7230	0.2340
	Course contents	Course contents were useful and they help learners follow and understand the lessons	0.7030	0.2040

Table 1 Overall course ratings

The overall course was rated positively. On average, learners gave a rating of 7.1 out of 10. A rating of 5 would indicate that learners were indifferent to the course, and a rating of less than 5 would indicate that learners were not positive with the course. As PjBL formed the underlying pedagogy in the FinTech course, a rating of 7.1 indicated validations of positive receptivity towards PjBL as a FinTech course pedagogical approach.

In addition, on an overall basis, PjBL teaching was rated with relative positivity, with a relatively narrow standard deviation. However, learners appeared relatively less satisfied with the PjBL assessment and its associated learning materials as part of course contents. Further, learners appeared to seek continuous reinforcement on how PjBL assessment tied back to the course learning outcomes.

Results of two separate pre-post course surveys are consolidated in Table 2. The mean and standard deviation (SD) of rating scores were computed, with 1 being the best and 0 being the worst. From Table 2, several interesting insights were gleaned.

Category	Indicator	Item	Mean	SD
Grading expectation	Grading	Learners believed they will score a better grade if conventional lecture-tutorial format was used	0.7027	0.2566
	Grading	Learners believed they will score a better grade if PjBL was used	0.6378	0.2531
Learning and application mastery of FinTech concepts using PjBL	Knowledge retention	Learners believed that PjBL helped retain the FinTech concepts better - End of course rating	0.7027	0.2242
	Knowledge retention	Learners believed that PjBL helped retain the FinTech concepts better - Start of course rating	0.7027	0.1922
	Understand concepts	Learners believed that PjBL helped them understand the FinTech concepts better – End of course rating	0.6811	0.2234
	Understand concepts	Learners believed that PjBL helped them understand the FinTech concepts better - Start of course rating	0.6757	0.2178
	Mastery and application of concepts	Learners believed that PjBL helped them master and apply FinTech concepts better - End of course rating	0.6703	0.2222
	Mastery and application of concepts	Learners believed that PjBL helped them master and apply FinTech concepts better - Start of course rating	0.6595	0.2303
Learner engagement and motivation	Motivation	PjBL motivated learners to work harder to understand FinTech concepts	0.6703	0.2717
	Preference	Learners preferred PjBL compared to conventional lecture-tutorial format when learning FinTech concepts	0.6541	0.2292
	Interest	PjBL helped learners develop a greater interest for FinTech concepts	0.6432	0.2316
	Attendance	PjBL motivated learners to attend classes to learn about FinTech concepts	0.6162	0.2279

Table 2 Grading, learning and learner engagement ratings

First, it appeared that learners formed expectations that PjBL was relatively tougher to achieve high grades, as compared to conventional lecture-tutorial course delivery formats. This was likely due to the unfamiliarity of assessment and its associated learning materials delivered in a PjBL format, and the need to utilize higher order thinking to formulate, synthesize and create a FinTech project artefact, as opposed to traditional lecture-tutorial formats. While studies have found that pessimistic attitudes toward future grades negatively influence evaluations (Millea & Grimes, 2002) (Stinebrickner and Stinebrickner, 2014), the results of this study were counterintuitive. In general, learners displayed an inclination towards PjBL compared to conventional lecture-tutorial style when learning FinTech concepts. Learners also felt motivated to work harder to understand FinTech concepts.

Second, questions were asked relating to learners' ability to assimilate and apply their PjBL learning with reference to the Bloom's taxonomy cognitive level of (i) knowledge (C1), (ii) comprehension (C2) and (iii) higher order mastery of application (C3), analysis (C4), synthesis (C5) and evaluation (C6) (collectively referred to as C3-6), using the question indicators of (i) knowledge retention, (ii) understanding concepts, and (iii) mastery and application of concepts respectively.

Results indicated that learners' expectations were matched pertaining to C1 of Bloom's taxonomy; learners believed that PjBL helped retain FinTech concepts, with no change in pre and post-course survey results.

Further, learners gave improved post-course ratings for learning in terms of C2 and C3-6 of Bloom's taxonomy. These implied that learners felt that they benefited from the pedagogy in terms of higher order learning, and their uncertainty of understanding and mastery of a subject matter were reduced post-course.

It was interesting to note that the average ratings were of the following relative magnitude: C1 > C2 > C3-6. On average, learners rated knowledge retention higher than concept understanding, and learners rated concept understanding higher than that of concept mastery. It was plausible that learners found that understanding and mastery of learning required more gestation time, and given a typical semester load of courses in an institute of higher learning, such PjBL learning could represent a challenge to in-depth comprehensive learning.

In view of this, learners' expectations will need to be managed. Learners will have to be continually reinforced that, aside from the breadth of FinTech concept knowledge acquired through course reading materials and lab activities, and the depth of FinTech research knowledge acquired within the project scopes, learners will also gain invaluable skillsets which will allow them to undertake similar research in other FinTech areas in their future work.

The experiential design nature of PjBL also meant that continuous reinforcements on how the PjBL assessments will tie back to the course learning outcomes are essential, as learners may lose focus of the learning objectives in midst of the long duration and multifaceted FinTech project assessments.

Qualitative analyses of pre-post course surveys – Learners' views on strengths and weaknesses of PjBL

This section discusses the strengths and weaknesses of PjBL as gleaned from learners' qualitative responses.

Strengths of PjBL

One repeated comment from learners was that PjBL is more suitable for a FinTech course. This was because learners were required to research during tutorials and this helped them to gain more insights and discover new information, compared to the conventional lecture-tutorial format as well as reading from textbooks. Learners were also able to obtain more updated information from their research and be familiar with the different technologies used in the FinTech industry. By conducting research on their own, they were also able to learn through various media, such as journal and industry papers, videos and infographics which aided their understanding of FinTech concepts. Learners also commented that having to research and look for information made the course more practical as this mirrored the real world in which they are expected to search for information during their work. Another observed that "…FinTech requires innovation. If FinTech courses are conducted in conventional styles, it [will be] difficult to come up with new and innovative ideas.".

Learners cited another strength of PjBL: it helped them learn more effectively as they were able to almost immediately apply the concepts learnt in completing their projects. The example one group cited was 'Financial Inclusion'. One learner in this group found the topic "very interesting and beneficial to the project and learnt the importance of FinTech for financial inclusion".

Many learners also preferred PjBL compared with having to sit for end-of-semester examinations as many believed "works better" for a FinTech course. One learner frowned upon examinations as merely "a competition of memory work". Learners also saw the advantage of putting in consistent work throughout the semester to complete their project. This is in contrast with the mundane last-minute cramming and memorization of concepts that are usually carried out to pass examinations.

Disadvantages of PjBL

One weakness of PjBL that learners pointed out was that the project allowed them to focus only on specific FinTech areas. Although they reaffirmed that PjBL facilitated their learning of different technologies in the FinTech industry, one learner commented that they only "…had a deeper understanding about the technologies that our group had focused on in the project". Learners had to be reinforced that, aside from the breadth of FinTech concept knowledge and the depth of FinTech research knowledge acquired, learners also gained invaluable skillsets which will allow them to undertake similar research in other FinTech areas in their future work.

As learners were divided into teams to complete their project, they were forced into meeting, communicating, and working with one another. This was another strength of PjBL which was recognised by learners as they valued the synergy of working in teams. Unfortunately, not all teams experienced this as some groups had to content with free riders. These uncooperative and irresponsible members would either be missing from discussions or not complete the tasks assigned to them by their group members. While the emphasis of team management in group projects enabled learners to gain soft skills of teamwork and communication, the presence of free-riders added stress and distraction to a proportion of learners who were relatively more conscientious and grade-conscious, detracting these learners from extracting the full value of PjBL.

Discussion and future work

This study presented the evaluation of a practical pedagogy of teaching FinTech concepts and applications through PjBL as opposed to traditional instruction. Several insights were gleaned from the quantitative analysis of the data obtained.

Results showed that learners were positive to PjBL-based instruction for the FinTech course under study. Learners preferred PjBL to semester-end examination as they benefitted from putting in consistent work throughout the semester. Pragmatic learners also acknowledged that having to research and look for information made the course more practical as it mirrored the real world where they are expected to search for information at their work. These positive learning experiences mirrored results in Li et. al. (2020).

Learners believed that PjBL could help them retain FinTech concepts better as they were able to almost immediately apply the concepts learnt in their projects. Learners also gave improved post-course ratings for higher order understanding and learning mastery. Moreover, PjBL helped learners improve their independent thinking, self and relational learning, and creativity and innovative thinking traits. Learners also expressed greater confidence in their own ability with less reliance on others.

As for working in teams, not all learners recognised the synergistic effect. Learners were randomly assigned into groups and could not choose their members for the group project. There were members who were extremely anxious about their grades while others were free riding on the strengths of others. Grouping could have been based on learners' strengths and weaknesses, and close monitoring of the progress of the various groups could be administered to counter the issues of group dynamics. These said, it is also critical for learners to be imbued core soft skills of learning how to collaborate with people from varying backgrounds, and coping with the team dynamics that may be presented to them. Growth of such soft skills may enhance students' ability to perform at their future workplaces.

In conclusion, this study validated the use of PjBL as a positive pedagogical approach for FinTech courses. The study provided an examination of the employment of PjBL pedagogical approach, and shared findings useful for the application of PjBL to FinTech education. For future research, it may be useful to extend the paper and propose improved ways of PjBL implementation, to better aid education practitioners on the delivery of PjBL-based FinTech courses.

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Technical Exchange Between Thai and Japanese Students Working on a Mekong River Joint Project

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Abstract

Yuge National Institute of Technology, Yuge College in Japan and Nakhon Phanom University (NPU) in Thailand are international exchange partner schools, and regularly conduct short-term study abroad programs. Yuge College is a college on a small island in the Seto Inland Sea, and NPU is a university facing the Mekong River, which flows through the borders of Thailand, Laos and Vietnam. Both schools are situated facing the waterside, and various studies are being carried out taking advantage of their locations. Until now, Yuge College and NPU have jointly developed an "environmental research boat capable of autonomous driving" for environmental research on oceans and rivers. In addition to bringing solutions to the outgoing joint project, the present study abroad program is aimed to train students to understand different cultures, communicate internationally, and become "earthlings" that can utilize the skills they have learned. In recent years, students in the departments of nursing and electric technology at NPU and students in the departments of electronic mechanical engineering and information technology at Yuge College have been working together on joint projects to solve particular problems as they contribute their ideas and skills. First, this paper reports on the development of an environmental research boat, the development of a maternity pillow and an automatic locker. Next, we report details of a recent project on the development of a leg elevation system for foot injuries. Then we report on the exchange activities of the Thai students and Japanese students who had taken part of this international exchange program, and summarize the results of the present project based on the questionnaire results. The results of this exchange project questionnaire show that both the Thai and Japanese students have gained the motivation to become "earthlings" who can understand the culture of each country and apply the skills they have learned.

Keywords: *International exchange, cooperative study, Environmental research, Technical cooperation, Health care*

Introduction

In recent years, the social economy has been globalized. Therefore, the National College of Technology (KOSEN) is training students to respond the needs of society. The Yuge College regularly conducts short-term study abroad programs with NPU in Thailand. We are working to foster international communication of our students by cooperating with both college students to solve current issues. We call such students "earthlings" who can utilize their learned skills and are capable to communicate internationally.

Yuge College is a college on a small island in the Seto Inland Sea, and NPU is a university facing the Mekong River, which flows through the borders of Thailand, Laos and Vietnam. Both schools are situated facing the waterside, and various studies are being carried out taking advantage of their locations. In recent years, the environment of the Mekong River has changed drastically, and its fixed-point observation is one of the important issues. Until now, Yuge College and Nakhon Phanom University have jointly developed an "environmental research boat capable of autonomous driving" for environmental research on oceans and rivers.

In recent years, students in the departments of nursing and electric technology at NPU and students in the departments of electronic mechanical engineering and information technology at Yuge College have been working on solving problems while providing their ideas and techniques.

First, this paper reports on the outline of our international exchange and the current situation of the Mekong River. Next, we report on the development of the environmental research boat and recent another initiatives for our exchange program. Furthermore, we will report on the activities between Thai and Japanese students as part of international exchange, and summarize the result of this project based on questionnaire results after the international exchange program.

Yuge college and NPU

Yuge National Institute of Technology, Yuge College is a school located on an island of Seto Inland

Sea in Japan, and is located next to the sea, as shown in Figure 1.

Figure 1. Sea near Yuge College

Figure 2. Mekong River near NPU

The NPU is located near the Mekong River in Thailand as shown in Figure 2. Both schools are conducting research that takes advantage of these characteristics. In this study, students in departments of electronic mechanical engineering and information technology at Yuge College and students in the departments of nursing and electric technology at NPU have joined the projects involved with environmental problems as well as health care related issues.

Thailand and Mekong River

The Mekong River flows from southern China to the Thailand-Laos border, passes through Cambodia and Vietnam to the South China Sea. The Mekong River is the longest river in Southeast Asia with a total length of 4620 km. It is an important river for Thai people to fish and trade daily necessities.

Thailand has two seasons in one year that are rainy season and dry season. In rainy season, maneuvering becomes difficult, because the flow speed of the Mekong River is high. In dry season, grounding accident frequently occurs, because its flow rate decreases. In recent years, due to the rapid development of economy, many dams have been constructed upstream of the Mekong River to meet power demand. For this reason, the environment in the Mekong River basin is changing significantly. Therefore, monitoring of environmental change is essential to the sustainable development of the Mekong river basin. As a new initiative to understand the topography of the Mekong River, Yuge College and NPU have been working together to develop an environmental research boat.

Past exchange results

Yuge College and NPU have exchanged 3 times. Table 1 shows the implementation years and the number of students of Yuge College. It has been 10 years since we started this program. In 2013, we had reported the results of this ongoing project. Also we reported at an international conference in 2015.

Table 1. Exchange results

Implementation year	Number of students
2012	7
2014	7
2016	4
2019	6

The process of this exchange is from Hiroshima to Taipei, and Bangkok to Nakhon Phanom in Thailand. While staying in Bangkok, we also visited local companies and Ayutthaya to learn about working styles and cultural differences.

In Nakhon Phanom, students of our school and NPU had been measuring the water depth of the Mekong River, and had been working on the development of an "environmental research boat capable of autopilot". As other program, students in the departments of nursing and electric technology at NPU and students in the departments of electronic mechanical engineering and information technology at Yuge College had been working together to solve issues of nursing.

The following sections describes these programs.

Development of environmental research boat

Based on the autonomous navigation algorithm developed by Tabusa et al., a new algorithm for surveying the riverbed of the Mekong River has been developed. Yuge College and NPU discussed and jointly developed a scanning boat model. After conducting autonomous navigation and remote maneuvering experiments of the developed system in Japan, a 3D topographic map of the riverbed was created on the Mekong River with the cooperation of NPU teachers and students. At present, the development of this environmental research boat is ongoing.

Figure 3 shows the experiment on the Mekong River.

Figure 3. Experiment on the Mekong River

Development of maternity pillow and automatic locker

In 2016, we developed a massage pillow for pregnant women and a smartphone app for its control, as shown in Figures 4 and 5. Engineering students developed both the hardware and software for the tasks proposed by the nursing students. A long pillow for pregnant women with a massage function has been developed so that control and music can be played on a smartphone.

We also developed an automatic locking application and locker shown in Figure 5. In this system, a house key can be locked anywhere using a smartphone.

Figure 4. Maternity pillow

Figure 5. Automatic locker

Development of "PUSH IT UP"

In the previous year, we developed a nursing device "PUSH IT UP" proposed by students in the department of nursing for people with foot injuries. The purpose of this development is to develop a device that allows a patient with an injured foot to freely raise and lower the foot on a bed. The students of the electrical technology department were in charge of creating the actual hardware, the students of the information technology department were in charge of controlling the software, and the students of the electronic mechanical engineering department designed the device.

The students first checked the purpose of the development and the necessary functions from nursing students using English, gestures, and a smartphone app. Next, the development of the control unit using Arduino, the design using CAD, and the creation of actual hardware were performed, and the development proceeded while communicating with each other. The communication is continuing even now, and development is proceeding. Several scenes of this project are shown in Figures 7 and 8. Figure 9 shows the completed "PUSH IT UP".

Figure 7. Software development and design

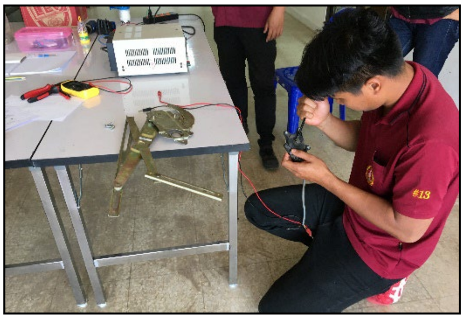

Figure 8. Hardware development

Figure 9. PUSH IT UP

Cultural exchange and tours

In addition to the collaborative projects described in the previous chapter, we also visited the facilities of each department on the NPU campus and visited their classes. The facilities and classrooms of the electrical technology department at NPU were of great interest to us, as they have some similar subjects to our school's electronic mechanical engineering.

This short-term study was held is in December. It was the dry season in Thailand. Besides that it was a special time of the year which is the time of the New Year Festival. The students interacted with local students by participating in an end-of-year sporting event, visiting the illuminations during the festival, and enjoyed having meals together.

Figure 10 shows one of the social event scenes.

Figure 10. Eating together

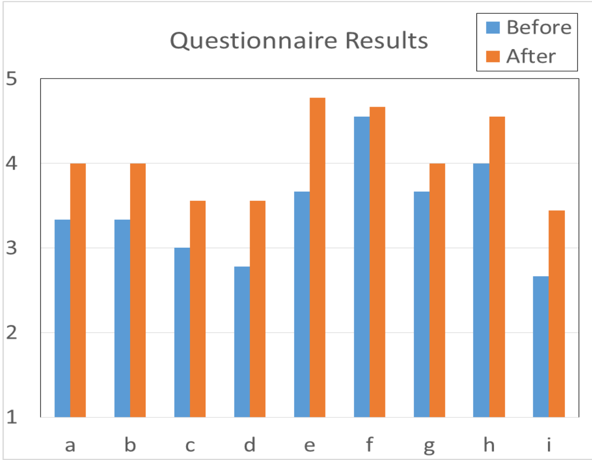

Figure 11. Questionnaire Results

Questionnaire Results

Questionnaires were administered to students before and after their short-term study abroad. This chapter summarizes the results of the questionnaires before and after the study abroad program. This questionnaire was compiled with reference to the Japan Student Services Organization's (JASSO) questionnaire for exchanged students, which was answered on a 5-point scale (1. Disagree to 5. Strongly Agree). The Questionnaires presented in this paper are as follows.

a. Able to take the initiative in finding issues that need to be addressed
b. Able to reach out to peers and take action to improve problems together
c. Think about the solution process for an issue and execute it in a planned manner
d. Able to take a leadership role in different places and within one's own cultural background
e. Able to actively communicate the meaning of a foreign language, even if it is inadequate
f. Understand and accept people who have different faiths and cultural backgrounds from their own
g. Have a strong motivation to study their area of expertise
h. There is motivation to study linguistics
i. Have a clear idea of the future direction and career path

The results are the average of the questionnaire results of nine students and are shown graphically in Figure 11. It was confirmed that all the items improved when compared to before and after the study abroad program. This indicates that the students have grown to be able to communicate actively even if they are not sure about their foreign language skills. Also, from item i, we can see that the students were able to grow to be able to think clearly about their own future.

Conclusions

This paper summarizes the results of Yuge College and NPU's short-term study abroad program.

Through this exchange project, both Thai and Japanese students were able to understand the culture of their respective countries and gain motivation to become "global citizens" who can apply the skills they have learned.

Acknowledgements

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DOES THE NEW PEDAGOGY COME? THE CHALLENGES OF ONLINE LEARNING AND TEACHING IN PRACTICUM-BASED EDUCATION DURING COVID-19 PANDEMIC

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Abstract

The World Health Organization has The World Health Organization has declared Coronavirus (COVID-19) as a pandemic in March 2020 which has posed a contemporary threat to humanity. Many countries have been lockdown and the restrictions have been imposed including the closure of shops and restaurants, the curfew and home-working for most people. The pandemic caused schools, colleges and universities across the globe to shut down their campuses in order to keep the social distancing measures among the students. For the sake of resuming the schooling in the pandemic situation, the education institutions have no choice but only could alter the conventional face-to-face teaching into the online mode.

It is not a new topic for using online learning and teaching in tertiary education. Most tertiary institutions are incorporating in their learning modes a number of forms of mobile technology likes learning management systems (LMS) and this information and communication technology (ICT) has improved collaboration between students and lecturers. However, even though the ICT has been assisted the teaching and learning for more than a decade, the completely online learning mode has never been implemented before COVID-19. As online learning is the use of internet and other important technologies to develop materials for educational purposes, instructional delivery and management of program, it brings the new experience and challenges to the students and lecturers in the crisis-response migration, in particular those programmes heavily weighing on practicum and skill training like engineering and tourism and hospitality. The administrative units of these programmes have not perceived online education to be a strategic initiative and pedagogy, nor is there an indication that future academic plans include online learning projects. It reflects that the obstacles or misconceptions on the online learning in practicum-based programmes have long been established.

This paper aims at investigating the experience of online learning and teaching from students and lecturers' perspectives. The semi-structure interviews were employed so as to reflect the myths, obstacles and challenges they faced and the crisis-response migration methods. The results show that the online learning mode has been gradually adopted by both students and lecturers but the face-to-face practicum is still irreplaceable in the vocational education.

Keywords: *Online learning, teaching, challenges, practicum-based education, COVID-19*

Introduction

Coronavirus disease 2019 (COVID-19) was first identified in December 2019 and it has spread globally to 210 counties and territories around the world. The disease has spread globally to 210 countries and territories around the world with a total of 157 million confirmed cases and 3.28 million death up to May 2021 (WHO, 2021). The mode of spread from humans to humans created the need for social distancing and avoidance of crowded places. Due to the pandemic, most governments have shut down all the schools and institutions to avoid the wide spread of the diseases.

In order to ensure more than 990 million students from worldwide are not left idle, the education departments of different nations have suggested the emergency remote teaching (UNESCO, 2020). The online teaching mode has been adopted abruptly to replace the conventional face to face teaching in all kinds of schools, including kindergarten, primary schools, secondary schools and tertiary institutions. Tertiary institutions are expected to be the one which have the most readiness for using the online teaching because the students are familiar with e-learning and online platform, such as learning management systems (LMC), online communication tools, and online learning resources.

Although the students in tertiary education are deemed to be the best group to using online learning, a number of concerns on the effectiveness of the online education pedagogy are raised. Generally, it is expected that most programmes in tertiary institutions are suitable to use e-learning but the programmes which heavily weigh on the practicum trainings seems to be neglected (Garcia-Alberti et al., 2021). Those programmes might encounter more difficulties than the others, such as arranging the skill labs, internship, and skill trainings, etc. Somehow it is questionable that whether these practicum sessions can be conducted online and how the students and lecturers perceive their value. Therefore, the objective of the present study is to investigate the effectiveness of the implementation of online learning on the vocational-orientated programmes, particularly in engineering and tourism and to explore the challenges and obstacles the students and lecturers face so as to review whether the new pedagogy can be adopted in the future vocational-based education.

Literature Review

The impact of COVID-19 on tertiary education in Hong Kong

Hong Kong, similar as other places in the world, heavily suffered from this pandemic. The first confirmed case has been found on 23 January 2020 (Lam et al., 2020). In May 2021, there are over 11,000 confirmed cases of COVID-19 in Hong Kong (GovHK, 2021). The figure has surpassed the number of confirmed Severe Acute Respiratory Syndrome (SARS) cases during its outbreak in 2003 (Hung, 2003). With the painful experience from SARS in 2003, the Hong Kong government has reacted promptly when facing the COVID-19, including the implementation of various control measures and compulsory quarantine. Even though the corresponding control measures have been conducted, various industries in Hong Kong have been suffered significantly, including the major economic pillar industries like tourism, retails, and finance.

The education industry cannot be stood alone from this pandemic and it has suffered seriously too due to the school closures. To reduce the risk of inflection, teachers and students needed to limit traditional face-to-face teaching and learning activities during the COVID-19 outbreak. In line with the guideline principles of "suspending classes without suspending learning" from the Hong Kong SAR Education Bureau (EDB), the tertiary institutions have to implement special protocols and guidelines for classes during the unexpected school closures. The online learning mode has been fully adopted starting from February 2020 and Goh and Wen (2020) comment that the online educational delivery poses a challenge on the relationship building between teachers and students as the online communication methods would influence psychological distance among people. Baker and Unni (2018) further point out that Asian students are more comfortable with lecture-based learning than with online learning because the concept of online learning is still relatively new in many Asian countries. Students with different cultural background learn differently and they have their preferences and approaches to learning. The learning approach in Asia generally involves memorizing study materials and content for the purposes of reproducing them when required. Therefore, Asian students prefer a teacher-centered learning approach. The effectiveness of interactive online learning mode in Asian countries is skeptical.

With the increased need for online learning during the pandemic, it is foreseeable that there are some advantages of online learning and also sacrifices online learners make when it comes to educational experiences. Online learning not only varies from general to discipline-specific fields of study, it also depends on whether the material in substance is a kind of knowledge-based learning or practicum-based skills.

The advantages and disadvantages of using online learning

Online learning as a substitution from traditional face-to-face / classroom teaching is inevitable around the globe especially during the COVID-19 pandemic. The switching from traditional classroom learning to online learning poses certain influences on the students and such end up as advantages and disadvantages during their study. Students taking greater numbers of online courses are more likely to engage in quantitative reasoning. However, in doing the online learning, students are more susceptible to access to the Internet and the associated web-based learning technology. Chen et al. (2010) stated that students who utilize the Web and Internet technology in their learning tend to score higher in the traditional engagement measures and are more likely to make use of deep approaches of learning like higher order thinking, reflective learning, and integrative learning in their study. The students are also reported higher gains in general education, practical competence, and personal and social development. Other than those personal achievement from students, the adoption of online learning provides the institutions as well as their students a much more flexible time and place of delivery of teaching (Smedley 2010). It also provides opportunities to ease barriers and encourage participation in discussion among students who may exhibit fear of talking to other learners (Arkorful & Abaidoo, 2015). Online learning is also a cost-effective in the sense of saving travelling time too.

There are also disadvantages of using online learning. Less likely to engage in collaborative learning, student-faculty interactions and discussions with diverse others are some of the typical drawbacks and also students are reported less exposure to effective teaching practices and lower quality of interactions (Dumford & Miller, 2018). Besides, online learning requires a very high degree of motivation and time management because of its inherit characteristics of remoteness and lack of interaction. When it comes to clarifications, explanations and interpretations, the online learning method may be less effective than traditional classroom learning. Communication and social skills are also affected negatively though students may have excellent academic knowledge (Arkorful & Abaidoo, 2015).

Moreover, in view of come practicum-based learning, the loss of reflective learning in / from practice within the conventional, missing spaces of schools is also identified by Kidd and Murray (2020). Chen et al. (2020) should come along with an online education platform capable to improving support services and the convenience of interactive communication, optimizing ease of use and enriching platform resource.

The application of online learning on practicum-based education

In shifting from traditional face-to-face classroom teaching into online learning, programmes with practical / field works poses huge challenge for teachers. A way to solve this problem is to change the practical work with another task, erase the practical work, students do at home or virtual lab. (Wisanti et al., 2021). The change of practical work requires teacher educators showing pedagogic agility. With respect to any of the changes, it also mixes learning and ICT with good circumferential resources. Thus, it is essential to have the support from MOOC (Mass Open Online Course) (Chen et al., 2020). Besides, within the pre-service teacher education programme, the importance of the practicum or placement in schools is widely recognised, with the practical space of practice gone, the on-line informal spaces became the new sites of learning (Kidd & Murray, 2020). The challenge is more serious when it comes into programmes like science and engineering curriculum. Though many software packages have been developed for simulation of real experiments but none of them are as effective as learning from undertaking real experimental work (Nedic et al., 2003). The authors also compared the advantages and disadvantages of remote laboratories, virtual and real laboratories. Jaya et al. 2020 further investigated the use of remote laboratories can be applied in vocational schools by looking at the results of development based on the validation of experts. Also the creation of online and real-time distance learning practicum systems that can facilitate students who are constrained by distance and inadequate school facilities too. Lastly, as Flores and Gago (2020) suggests, the learning in and through the practicum, the process of exploration will be long and part of an ongoing adaption process on the part of all stakeholders.

Methodology

The purpose of this study is to investigate the experience of online learning and teaching from engineering and tourism management students' and lecturers' perspectives. In order to explore the detail challenges and obstacles they faced during the COVID-19, the qualitative research method was employed in this study. The focus group interviews were used because it has high face validity and flexibility. Meanwhile, the group dynamic can help stimulate the conversation and reaction so as to obtain the in-depth data.

Four focus group interviews were conducted. Each group had 8-10 participants. Here are the profiles of the participants:

Group 1: The students who are studying in sub-degree, majoring in building services engineering and computer and electronic engineering.

Group 2: The lecturers who teaches sub-degree engineering programmes in tertiary institutions.

Group 3: The students who are studying in sub-degree, majoring in leisure, tourism, hospitality and event management.

Group 4: The lecturers who teaches sub-degree programmes in leisure, tourism, hospitality and event management in tertiary institutions.

Below are the major protocols and control measures of the participants' institutions during COVID-19:

1. The educational teaching and learning activities were conducted through online classes or webinars starting from February 2020;
2. All staff are advised to work from home;
3. All staff and visitors were required to report their travel declaration and health status form to the school before entering the campuses;
4. All students are not advised to visit the campuses unless any emergency;
5. Blended practicum sessions were conducted in the view of the stable situation; and
6. Portable computer lending scheme were launched for those students or staffs who have the needs.

All the participants have either arranged the practicum sessions or participated in the practicum sessions in their corresponding academic programmes while the practicum sessions weigh heavily in the structures of the academic programmes. The interviews were conducted during March to April 2021 and each focus group interview was lasted around 1 to 1.5 hours. Content analysis was employed in order to make inferences by identifying the characteristics of the messages systematically. It aims at getting the pattern of the data and categorizing into different themes.

Results and Discussion

The researchers identified the research topic through the text and the text was integrated into key labels and themes. The students and lecturers who responded to this study indicated that there were a number of challenges for them to adopt the online learning and teaching during COVID-19. The results of the focus group interviews will be categoized under two perspectives—students' perspective and lecturers' perspective. Meanwhile, there were six major parts: 1) Mentality issue, 2) Environmental issue, 3) Communication issue, 4) Technological issue, 5) Interactive issue, and 6) Industrialized practical issue.

Students' perspective

Students are playing a passive role in the change from traditional conventional learning to the online learning under the pandemic because the online learning seems to be the only way for them to continue their study. Even though they are familiar with e-learning platform, it is probably the first time for them to have the online learning including having the real-time online lessons. During the interviews, they showed their concern on the following three issues:

1. Mentality issue

Due to the first time to have real-time online lessons, students found that their learning motivation had been strongly reduced and they were not able to focus till the end of lessons:

I do not turn on the camera because I do not want to show my face to everyone in the class. I can lay on the bed to have class and therefore I cannot focus and listen attentively for most of the classes. The lecturers even do not know whether I am listening. Who cares? (Student A, majoring in building service engineering)

I usually log into the Zoom and then go to bed again. How can I attend the class at 9:00am? It may be better if I go to the campus to have classes but I really cannot find any motivation to have online class. (Student D, majoring in tourism management)

2. Environmental issue

Even though Hong Kong is a developed city, the Gini Coefficient index of Hong Kong is still higher than USA and Singapore. It reflects that the wealth gap between the rich and poor is relatively large. Some students presented that their homes were not suitable for having the lectures:

How can I have classes in my home which is only smaller than 300 sq. ft. but with five people? My family members are all together and I cannot have a quiet place for attending the lessons. (Student E, majoring in hospitality management)

I borrow the notebook from the College but the wifi at my home is very unstable. I am so annoyed that I cannot have a full lesson without any cut-off. (Student H, majoring in computer engineering)

3. Communication issue

As all the students stayed at home, it was difficult for them to meet their classmates and the chance for group discussion was very rare. Without meeting their classmates, their group project could not be conducted smoothly:

You know, the nature of engineering project is to work as a team, how can you build a building alone? But I cannot meet my classmates for a discussion during the pandemic. I do not know how to do the project. (Student G, majoring in building service engineering)

Some assignments are group presentations. Actually, I do not meet my classmates personally and it is difficult for us to discuss the project online. I even do not know their personality and working style. We like the net friends rather than the classmates. (Student B, majoring in leisure and tourism management)

Teachers' perspective

Teachers are taking the dominant role in leading and to deliver the online learning. Thus it is of paramount important that the learning be able to arise the interest of the students. Though digitalisation and e-learning platform are commonly adopted mode of teaching, a full implementation of online learning is also a big challenge for teachers to cater for the pandemic for the first time. During the interviews, the teachers showed the following three issues:

1. Technological issue

With the online learning to be implemented in a short period of time, the reliance on the use of hardware and software is inevitable:

I am teaching in engineering field of study. I have not problem in explaining the theories and principles to the students using PowerPoint slides. But it is out of my control in working on a mathematical step by step derivation or even harder in using diagrams / figures to help in explanation of complex engineering systems. (Teacher A, teaches building service engineering)

We focus on experimental learning experience. Without the site visits to the facilities, the students cannot fully understand the latest development of the industry. (Teacher C, teaches leisure and tourism management)

2. Interactive issue

Eye contact, facial expression and body language always helps passively in identify the ambiguities of the students when face-to-face classroom learnings are to be held. Once online learning is fully implemented, the above observations could not easily be obtained:

Those facial expression or body movement poses important features which shows how much they can get from the lectures and upon such observations, it is easier for me to get in touch with the inner side of the student. However, with online learning facing a computer screen, it is unable to have a clear picture to observe all students, let alone that even most of the students are unwilling to switch on their camera. (Teacher B, teaches building services engineering)

In the field of tourism, the skill of face-to-face communication is essential in guiding and leading the customers. Thus, observation from their facial expression is quite important. It comes with high difficulties in demonstrating these the combined expression of body movement and courtesy through a camera or computer screen. (Teacher D, teaches tourism management)

3. Industrialised practical issue

In some discipline-specific areas of teaching, the nature requires the members to work as a team to complete a large project. Each member has his own position in the project that fills for his talent. As such, communication among the members is essential from time to time in order to integrate the project from pieces.

In the field of engineering, a large project usually involves a number of professionals which come from different areas of expertise. In order to have a smooth integration from different areas, frequent communication and discussion are essential. Site inspection for preventive maintenance is always a must for frontline engineers. Online learning is hard to serve the purpose. On the other hand, if site inspection cannot be carried out, it would be hard to identify the defects from the systems and to advise on the possible solutions. (Teacher J, teaches building services engineering)

In the field of hospitality management, confrontation / practical skills with customers are daily routines that every employee faces. The lack of face-to-face learning hinders the students' effective learning from interview skills and grooming before attending the interview with internship employers. (Teacher E, teaches hospitality management.)

Conclusions

Throughout the focus group interviews, it is found that both students and lecturers encountered different challenges when using online teaching and learning. The preliminary results show that the online learning in the practicum-based programmes may not be as effective as the other programmes. As the structure of the programme, the programme intended learning outcomes, the course intended learning outcomes, and the course assessments are linked together closely and they have been formulated under the traditional face-to-face learning environment, it may cause the substantial difficulties for the lecturers to change to the online teaching mode and online assessment for fullfiling the course intended learning outcomes properly. In addition, the skill-based trainings and practicum emphasize on the hands-on experience and interactions between the students and lecturers, particularly in the sub-degree education. The students are expected to learn certain skills throughout their study. Once the students cannot equip the para-professional skills, it may impact on their employability after graduation. Such consequence may cause a ripple effect on the number of potential students' application and admission figure. As a result, it is concluded that the practicum sessions is still irreplaceable in the vocational-orientated programmes like engineering and tourism management. Unless there will have tremendous technological development on the virtual practicum sessions, otherwise the needs of face-to-face practicum is still existed. After the online teaching and learning experience from COVID-19, it seems that the blended learning mode is feasible in the vocational-orientated programmes (i.e. online mass lecture plus face-to-face practicum) but whether the entire online learning can be adopted as the new pedagogy is still questionable.

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COPING WITH UNCERTAINTY IN LEARNING – CASE PROJECT HATCHERY

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Abstract

The world is rapidly changing with and without Covid-19, with most areas of society facing a turning point. We live and work in a VUCA environment: Volatile, Uncertain, Complex, Ambiguous, where the strive for innovation has become the standard. Organizations seek for employees who are creative, resilient and innovative problem solvers with professional abilities in coping with rapid change. All this requires tolerance for uncertainty.

The ability to handle uncertainty in a productive manner is crucial for the present-day professionals, the organizations they work in, the educators that educate them and for the society, they contribute to. Although education plays a critical role for making the necessary changes, educators may lack the knowledge, skills, and tools to support their learners to develop their abilities to handle uncertainty in a positive, generative and productive manner. Without embedding uncertainty in the learning processes, as a part of professional and personal development, coping in the VUCA environment can lead to stress, anxiety, and vulnerability, hampering a growth mindset of students and employability of graduates.

Innovation pedagogy is a learning approach aiming to train innovative experts who have the required competence enabling them to participate in the versatile innovation processes of their professional career. This goal can be reached when learning environments are designed to simulate innovation processes, where students' have to use their study field specific competences and innovation competences. By supporting the development of innovation competences students' abilities to handle uncertainty in a positive, generative and productive manner are promoted.

In this article we present one of the innovative learning environments developed and implemented at Turku University of Applied Sciences and analyze how uncertainty is present in this learning environment called Project Hatchery. First, we describe the theoretical background of VUCA and innovation pedagogy and introduce the concept of the Project Hatchery. Then we present the main results how uncertainty is present in this case and how students can be supported to tackle the feeling of uncertainty and deal with productive manner. Finally, we reflect and conclude our experiences according to the results. This article not only brings new insight to the topic of uncertainty in learning but also can serve as an example to pedagogic development when educating future professionals.

Keywords: *uncertainty, competence, learning, innovation pedagogy, future professional*

Introduction

The competences needed in coping with the turbulence and with the increasingly frequent change as well as the uncertainty it causes, is also facing us, educators, both in the way we approach the designing of the learning environments and how we teach in this environment. However, in an educational setting, learning is often well planned, phased, and structured, although being conflicted in the real VUCA world where we are living and working.

The VUCA acronym is standing for Volatility, Uncertainty, Complexity, and Ambiguity that describes a turbulent environment, often referred in the context of leadership theories (Pasmore & O'Shea, 2010; Horney, Pasmore, & O'Shea, 2010). According to Hänti et al. (2021), the VUCA world has been characterized by many interconnected parts and variables. Although information can be available, it is typical for the VUCA environment that the amount of information is too overwhelming as well as it is difficult to process (Fadel & Groff, 2019). Additionally, the causal relationships are nor clear and this is leading to complexity and even situations of “unknown unknowns” (Bennet & Lemoine, 2014). This makes the problem unstable and possible solution actions unclear and uncertain. High mobility of people and goods and services have broadened the sphere of activities and the global trends and megatrends are widely spread at a fast pace. Reconfiguration at a mental, technological, and physical level and evolving technological interconnectivity (Codreanu, 2016) form an ongoing process that changes the ways people are acting in their private and working life. This all makes the insights of the future working life unstable, obscure, unpredictable, fuzzy, and even chaotic. (see also Hänti et al., 2021)

To survive in VUCA world handling uncertainty in a positive, generative, and productive manner is a key ability. According to Bollinger & van Rooijen (2021), uncertainty can be classified as positive (activating, eustress) and negative (inactivating, distress) experience having also mental and physiological effects (Bigdeli, 2010). Viewed form the negative perspective, uncertainty can be experienced as a source of threat, anxiety, and fear (Majerek, 2018 referred in Bollinger & van Rooijen, 2021) with the result that it can decrease creativity, weaken performance, and make people resort to safe work practices or methods (Savijärvi, 2016). Instead, from a positive side uncertainty can be interpreted as a growth factor, a driver for creativity and innovation. As a professional skill, it is powerful and productive to be able to view uncertainty as a rich source of opportunities, as it can offer the possibility to create new forms of thinking and acting (Joosten, 2021, referred in Bollinger & van Roojien, 2021). Positive uncertainty opens new possibilities for action and thus implies a goodbye to dogma’s and limitative normative frames (Jacobs, 2010, referred in Bollinger & van Rooijen, 2021). It is also a prerequisite for developing the ability to deal with open-ended problems in the future (Muukkonen & Lakkala, 2009). Overall, uncertainty can be an essential dimension of future professional competences (Attard, 2008; Lane & Maxfield, 2005).

To response the needs of VUCA world and the requirements of future-professional competences, it is necessary to prepare our students to handle uncertainty in a positive, generative, and productive manner, without being stressed. All this requires versatile experiences and learning situation intensively during their study path. Thus, we as educators should consider how to equip the students with such competences needed in both personally and professionally. All this requires carefully designed learning environments, wherein students can experience and train acting in VUCA world but in a safe and supportive manner.

To fill the competence gap of handling uncertainty productively the aim of the PUNC (Professional UNcertainty Competence) project is to professionalize educators to enable learners to develop their uncertainty competence in their professional performance to find a way through this increasingly uncertain, changeable, and ambiguous world. In this Strategic Partnership, six partners, from different corners of Europe (from Poland, Finland, Netherlands, Denmark, and Spain), combining their expertise, exchanging knowledge, and learning from one another’s cultures among educators and researchers on the themes of learning, competence, and pedagogies.

The aim of this article is to show how VUCA world can be simulated in authentic educational situation, as a one selected case in the PUNC project. We present one example of innovative learning environment, called Project Hatchery; developed and implemented at Turku University of Applied Sciences, analyse how VUCA is present in this context and reflect how students can be supported to tackle the feeling of uncertainty in productive manner. Finally, we conclude our experiences according to the results. This article not only brings new insight to the topic of uncertainty in learning but also can serve as an example to pedagogic development when educating future professionals.

Materials and/or Methods and/or Pedagogy

Innovation pedagogy is a learning approach with an aim of developing innovative experts who have the required knowledge enabling them to participate in the versatile innovation processes of their professional career. Innovation pedagogy supports the argument that through social interaction students may reach a higher state of development than they would achieve by working and studying on their own. When different actors (e.g., teachers, students, working-life representatives) are able to work together in dialogue in such manner that their own expertise can be efficiently shared and combined in fresh ways, it results in something more than the sum of its parts. This process also enables novel knowledge creation and understanding based on the thought and ideas presented by others. Moreover, according to innovation pedagogy, when the purpose of the universities of applied sciences supporting regional development is integrated to the learning process, achieving intuitive learning and tacit knowledge from practices and culture of community with facilitation is possible. (e.g., Kettunen, et al., 2012.)

In practice, the aim of innovation pedagogy is to generate learning environments wherein learning takes place by applying knowledge by doing and experimenting in a problem-based manner in the context of working life. Learning also occurs trough collaborative learning, not only from and with others but also from different sources of information in a multidisciplinary manner, by creatively combining different competences and experiences. (Keinänen, 2019). From educators this requires supporting, encouraging, and guiding, in order to make life-long learning, collaborative working methods, combination of different expertise, and utilization of reflection and feedback possible. It also involves not only competence in activating teaching and learning methods, and in planning and implementing successful teaching and the learning processes but also competence in co-operation and networking with working life organizations, in flexible study paths, in internationalization and entrepreneurship (Konst & Scheinin, 2018).

A learning environment is most frequently understood as the physical (e.g., a classroom or campus) or virtual premises and spaces (e.g., learning systems or platforms), meant and built for learning purposes, wherein we share the description, contents, and goals of the study unit. Some authors have been rethinking a learning environment from psychological and physical perspectives, e.g., the psychological comfort with space as well as the motivational and inspirational effects of space. However, the concept of social learning environment is often neglected in this discussion, although in the VUCA word problems are solved and innovations are created in groups and networks. Solving wicked problems requires people from many different disciplines who are expected to work effectively together, and knowledge and skills which do not belong to the scope of one and only discipline. According to innovation pedagogy, the social aspects of working and learning are emphasized and group processes where learning happens in teams form an essential part of the whole process of learning. A social learning environment is formed by people with different talents and competences and by the interaction enabling collaborative learning. (Hänti et al., 2021).

Following the bases of innovation pedagogy and definition based on Hänti et al. (2021), in this article, we define a learning environment to indicate educational arrangements or systems that are designed and managed. In addition, we underline that a learning environment is both the socio-cultural and the physical/digital settings where learners perform their tasks wherein connectivity plays a key role by referring to the relationship between work experience, learning and knowledge (Hänti et al., 2021).

Project Hatchery concept is one of the methods of Innovation pedagogy and developed and implemented at Turku University of Applied Sciences (Turku UAS) since 2008 (e.g., Kairisto-Mertanen & Keinänen 2020). Project hatchery course (5 ECTS) includes project working in practice and theory of project management and it is delivered at the very beginning of the studies for first-year students. Project hatchery work is applying the CDIO model. Each multidisciplinary group of 10-14 students has their own real-life project, that group will execute independently. The aim of the project hatchery is to provide basic skills for the project working and to support succeeding in the more demanding project study units or modules following years and to support students active and responsible role as a learner not only in the individual level but also as part of a project team. (e.g., Kairisto-Mertanen & Keinänen 2020.)

Every project hatchery group has a teacher tutor. Teacher tutor’s role in project hatchery is rather supportive than academically educative. Thus, for a project group teacher is available but does not have a central role. One teacher is responsible for coaching of three to four student tutors. Additionally, every group has a second-year student tutor, who already has a first-year experience of project hatchery. This is called Leading a team course (5 ECTS), which is an optional course aiming to orientate second-year students to basic principles of group leading (i.e., group dynamics, management, motivating, steering) through theory and peer learning methods. Afterwards these second-year student tutors will apply achieved theory into practice when leading their own the project hatchery. (e.g., Kairisto-Mertanen & Keinänen 2020).

The CDIO Initiative educational framework is adopted in Turku UAS and the structure of the project hatchery is designed as a first-year design-implement experience. The design-implement experience refers to a process of developing new products or systems. By including design-implement experiences in a curriculum, students are given opportunities to design and build products in real-world context (Young & Hallström, 2007).

Conceive-design-implement-operate (CDIO) -model defines the stages of Project Hatchery (Figure 1).

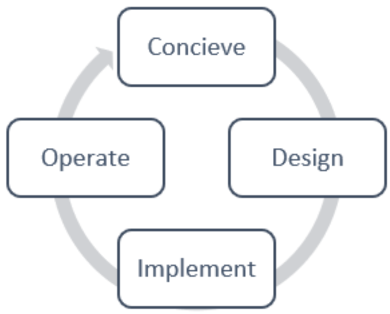

Figure 1. The stages of the CDIO-model (Young & Hallström, 2007).

In the first phase, conceiving, the project hatchery students form project teams, learn the principles of Project Hatchery concept and the project assignments are introduced. Students get familiarized with the theme of their project assignment and find the scope, objectives and goals for their project. In the designing phase the project plan is completed and ideas to execute the project are generated. Implementing means executing the project. The students work with their assignment and carry out weekly routines such as project meetings. In the final stage, operating, the project outcomes are presented and reported. Reflection and peer-evaluation are an essential part of the learning process and they are combined to closing the project.

Results and Discussion

In order to understand how uncertainty can be part of the students' learning processes and how it can be handled in a positive, generative and productive manner, Project Hatchery was analyzed by applyign the VUCA framework as an analysing tool (see also Hänti et al., 2021). First, we identified how the elements Volatility, Uncertainty, Complexity, and Ambiguity are occuring in the learning environment. Second, we recognized the actions to tackle these issues to convert threats to opportunities and help the students to turn possible anxiety to enthusiasm.

Volatility can be seen as lack of stability. The elements that express volatility in Project Hatchery are presented in Table 1. Of the aspect on volatility heterogenic and multidisciplinary groups, unfamiliar group members and changes in the group members during the course have been identified as factors that indicate lack of stability. Students can't select the group or the subject of the project which may also create instability. The feeling of loneliness and being unconfident can enhance lack of stability.

Volatility	
Occurence	Lack of stability - heterogonic and multidisciplinary groups - unfamiliar members in the group - changes in group members - group and assignment are given, not selected
Tackling	- grouping is supported - the pedagogy and the way of working is justified and discussed - the students are motivated by bringing the needs of the modern working life visible in the course

Table 1. Occurence and Tackling of Volatility in the Project Hatchery.

Actions are taken to tackle these issues (Table 1). The pedagogy and the way of working is explained to the students in the beginning of the course and discussions continue during the course. The justification is based on the needs of the modern working life and the students are motivated by using this framework. The grouping is supported by student and teacher tutors. One of the main duties of the student tutor is to support the student group in grouping. The student tutors support single students to become a member of the group.

In the Project Hatchery environment, uncertainty seems to appear in several ways (Table 2). The roles of the teacher and the students differ from the prior experience most first-year students have from their previous studies, e.g, upper secondary school or vocational education and training. The project hatchery is not traditional teacher-centered course, and the students must take the responsibility of their own learning as well as carrying out the project work as a group, which increases uncertainty. Additionally, uncertainty can occur because as the students are first-year students, they don't necessarily trust their capability to complete the project. The project subject and the project group are new for them. First-year students might not have any prior knowledge of the subject or project work.

Uncertainty	
Occurence	Lack of knowledge or adequate information - no prior knowledge about the assignment or project work - new roles and responsibilities of students and educators (not teacher-centered) - 1st year students do not trust their capability to complete the projects
Tackling	- the process is defined - student tutors support - teacher support - self-reflection and group reflection - feedback from the student tutor

Table 2. Occurence and Tackling of Uncertainty in the Project Hatchery

However, there are several measures to help the students to tackle the uncertainty (Table 2). Student tutors have a crucial role in supporting the first-year students in finding a way to study in the university of applied sciences. Teacher tutors' role in project hatchery is also rather supportive than academically educative. The working and learning process in the project hatchery is defined and illustrated, which supports handling the feeling of uncertainty. Moreover, reflection is used as a tool in recognizing and evaluating the learning during the course. There is a self-reflection in the beginning and at the end of the course. Group reflection and peer evaluation at the end of the course are utilized to learn assessing and giving others constructive feedback, and helping also to tackle the uncertainty. Student tutors' feedback during the course as well as at the end of the course motivates and supports the students.

Complexity can be seen as overwhelming number of variables (Table 3). Unclear assignment and lack of specific tasks are examples of the presence of complexity in project hatchery. In addition, changes are likely to happen during the course. For example, changes in group members or in project assignment. The unclarity may cause difficulties in setting the focus or in prioritizing the tasks.

Complexity	
Occurence	Overwhelming number of variables - several issues are changing during the course - all the tasks are not defined in detail - difficult to prioritize or set the focus
Tackling	- discussions - student tutors support - teachers support

Table 3. Occurence and Tackling of Complexity in the Project Hatchery

Complexity is tackled through discussions and support (Table 3). The student tutor and the teacher are available and if needed they help the group in finding the way to continue their work. Neither student tutor nor teacher offer ready-made solutions but support the group or individuals in finding the answers.

Ambiguity is present during the whole course (Table 4). The expected project outcomes are not defined in detail and the student groups have a freedom to decide the way to carry out the project work. It is not defined by the project owner or teacher. The criteria for excellent work is also unclear and the students must evaluate their work and results themselves. Teacher is always not present, and no detailed instructions are given. Teachers' role is to support the student tutor and the group in the background. Teacher supports when needed, but other times she/he is invisible. Working in the course is based on group work and students that are used to working alone may find it challenging, mavericks fail.

Ambiguity	
Occurence	Lack of clarity or understanding - teacher is not telling what to do - the expected project outcomes are not defined in detail - the criterion for excellent work is unclear or not defined - there is not only one way to do the work
Tackling	- the group is instructed and supported to plan their work - project goals are discussed with the project owner - student tutors support - teachers support

Table 4. Occurence and Tackling of Ambiguity in the Project Hatchery

Planning and setting the goals are essential if the ambiguity is to be tackled (Table 4). A project plan, schedule and weekly meetings are tools to plan the work. Early in the course the groups make a schedule and a project plan that they follow and if necessary, update. The project owner sets goals for the project even though she/he does not tell how the work should be done. Once again, the support of the student tutor and teacher is identified as a tool to overcome challenges.

Conclusions

The aim of this article was to show how VUCA world can be simulated in an authentic educational situation, in one innovative learning environment called Project Hatchery. In this article, we analysed how VUCA framework is present in this context and reflected how students can be supported to tackle the feeling of uncertainty in productive manner. As conlusions, we higlight four points as lessons learnt of our analyses.

First, althoug the framework of VUCA is rarely used structure in educational context, and applied more in the context of leadership theories (Pasmore & O'Shea, 2010; Horney, Pasmore, & O'Shea, 2010), this article showed that it is also practicable in education. The VUCA framework can be used as an analysing tool for curricula development and design.

Second, one of the key points in mastering the VUCA elements in the mentioned learning environment is sufficient support. The student tutors are crucial actors supporting the first year students. The teacher must allow the student tutors to do their work without interfering, but supporting the student tutor in the background and intervening only if asked or needed.

Third, another element supporting students to cope with e.g. uncertainty is the clear structure of the course. The concept of project hacthery is described and the course structure is planned and documented. This forms the backbone that the student and teacher tutors can lean on and use as a tool, but still allowing for first-year students the freedom to plan their work and studying independently on the group level. There are all together nearly 1500 students and teachers involved in the project hatchery. Shared understanding of the goals and the stucture of the course is essential.

Fourth, overall, it was a useful and educational exercise to do the VUCA analysis. It gave new insights into teacher's work and into the development work of the project hatchery concept. However, aiming to embed uncertainty in the learning processes, as a part of professional and personal development, recuires this kind of analysis more broadly than only one course or learning environment. Therefore, as next steps, the analys should be enlarged in degree level and different project-based learning environments simulating VUCA world. Thus, the analyses not only promotes the professional uncertainty competence development during the degree but also it supports the curricula development in critical phases. Additionally, what comes to the future studies, it would be crucial to collect also students' experiences and perceptions on different phases of their studies and in different kind of broject-based learning environments.

To prepare students for the working life in the VUCA world the curricula and the learning environments necessitates intentionally designed learning environments for recognizing VUCA and thus understanding as well as motivation to allowing change, unpredictability, professional uncertainty in a positive and productive manner. This article presents one example how that can be ipmlemented. Thus, the article not only brings new insight to the topic of uncertainty in learning but also can serve as an example to pedagogic development when educating future professionals. This article hopefully inpires for further pursuits and encourages researchers and educators to unbdertake this subject.

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The Path to a Double Degree Program Agreement between Nagaoka KOSEN and TUAS – from the Perspective of Nagaoka KOSEN –

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Abstract

The agreement for a double degree program was signed by National Institute of Technology, Nagaoka College (Nagaoka KOSEN) and Turku University of Applied Sciences (TUAS) in November 2020. This paper will introduce how we reached the double degree program's conclusion and what challenges we faced along the way. In the case of Nagaoka KOSEN, the term "students" here refers to advanced course students. Before we discussed this program, we came up with an academic agreement between Nagaoka KOSEN and TUAS. Students at both schools would be able to study at either campus for a duration of three months. Staff at both institutes started discussions about the double degree program in early 2018. After a while, at Nagaoka KOSEN, we noticed that we did not know much about double degree programs nor TUAS. This was the first obstacle. We had many inquiries for TUAS from autumn to winter in 2018. In early 2019, we traveled to Turku, Finland and discussed this program in person. We found some major differences between our school curriculums. One of them was regarding internships. This was the second obstacle. Nagaoka KOSEN had short internship courses at that time, but TUAS has had a prolonged internship period for its students. Due to the fact that Japanese schools usually do not give students long summer holidays, Japanese students take internship courses lasting shorter durations than those offered in Finland. The third obstacle was the course length. For Turku, this is a minor problem, but for Nagaoka, this is a major obstacle. That is because Nagaoka students can not obtain enough credits and take about 5-months of internship within two years. Our solution was to extend the length of Kosen's Advanced Course program from two years to three years for students enrolled in this double degree program. Discussions were held in May 2019, in September 2019, and in February 2020. Although We finally came to an agreement, this program can be improved. Since this program has just begun, we expect to encounter further challenges in the future. However, we are confident that through cooperation with TUAS we will be able to continue to solve these challenges as they arise.

Keywords: *double degree program, higher education, collaboration, international affairs*

Introduction

In Japan, the need for global education has been gaining attention for the past 10 years. National Institute of Technology, Nagaoka College (Nagaoka KOSEN), has a history of international student exchange.

Nagaoka KOSEN is one of the earliest Japanese KOSENs that have received international students since 1985, making it one of the earliest Japanese KOSENs to do so. However, we did not receive so many international students until 2009. Therefore, our school set up the Chikyu-lab, a place to support students who are interested in international exchange, in 2009 to foster support in developing a global mindset in both Japanese and international students. As a result, from around that time, the number of international students we accepted began to increase (Figure 1).

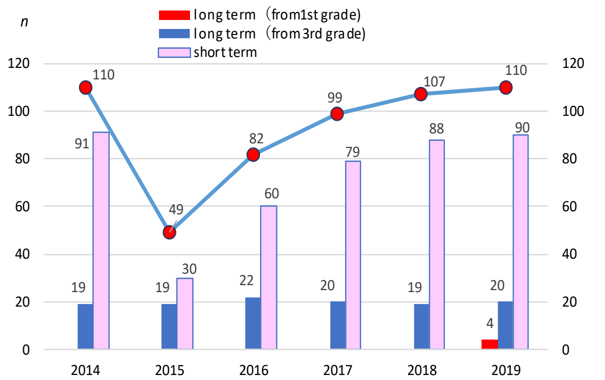

Figure 1. Number of overseas students accepted at Nagaoka KOSEN

Nakamura (2016) summarized the recent achievements of international exchange activities at Nagaoka KOSEN in his report. He stated, "the reason for tackling such an international exchange activity at the institute is to meet the requirement from the society which advocates that the academy should foster students in order to possess broader views of globalization. Nagaoka KOSEN has experienced their studies abroad in countries such as China, Malaysia, Thailand, Vietnam, Singapore, Mongolia, Finland, France, Russia, and Mexico. Not only have the students in Nagaoka KOSEN studied abroad at overseas institutes which have academic exchange agreements with the institute, but also students from these overseas institutes have visited the institute."

Turku University of Applied Sciences (TUAS) is an innovative university in Southwest Finland with about 10,000 students. This university is dedicated to the creation of international competitiveness and well-being. The course programs are relevant to working life because they combine theoretical studies with practice in professional skills. A new approach to learning developed at TUAS is the core of their teaching strategy. About 800 international students are enrolled at TUAS. Every September, many international students are welcomed to the TUAS campus (Figure 2).

Figure 2. Orientation for international students at TUAS

In the case of students from Nagaoka KOSEN, they stated that they were satisfied with the tutor system provided to them at TUAS.

First obstacle

We would like to explain the collaboration between TUAS and Nagaoka KOSEN. We began to talk about our collaboration with TUAS in December 2017. In March 2018, The first agreement between TUAS and Nagaoka KOSEN was concluded (Figure 3). In that year, Nagaoka KOSEN sent four students to TUAS for the first time.

In 2018, Nagaoka KOSEN made a new working group to execute a double degree agreement. However, all of the group members did not know much about double degree programs nor TUAS. Thus, some information was needed to be passed on to new members by the staff involved in the first agreement between TUAS and Nagaoka KOSEN. Our knowledge about TUAS was increasing, but we still knew very little about double degree programs. None of KOSENs had ever offered a double degree program before. We then researched Japanese universities and found that only a few of them have double degree programs. Furthermore, many of them are offered at the master level only.

Figure 3. The agreement between Nagaoka KOSEN and TUAS

We realized that there were so many things that we did not know. We had many questions to TUAS from autumn to winter in 2018. In early 2019, we traveled to Turku, Finland and discussed this program in person. (Figure 4).

Figure 4. Discussion about double degree program at TUAS

We found some major differences between our school curriculums after this meeting. One of them is how to count a credit. At Nagaoka KOSEN, there are not so many subjects in 4th and 5th grade called "gakusyu- tani kamoku" : 1 credit = 45 hours study (Figure 5). This is a problem when converting to ECTS.

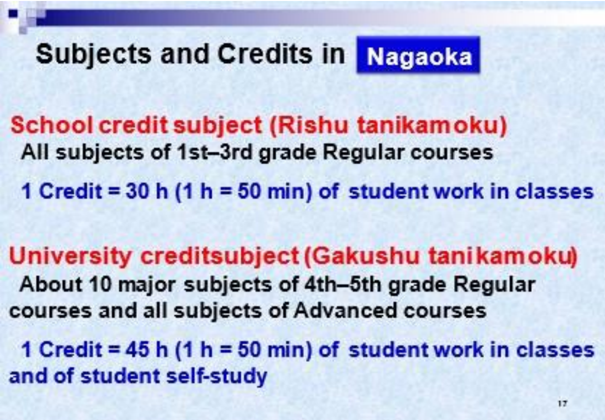

Figure 5. Subjects and credits at Nagaoka KOSEN

Second obstacle

Nagaoka KOSEN had short internship courses at that time, but TUAS has had a prolonged internship period for its students. Japanese schools usually do not give students long summer holidays. Most Japanese universities have short breaks in the winter and spring and longer breaks in the summer. The summer break, however, is not so long compared to the universities in European countries and in the United States. In recent years, even in Japan, there has been a growing demand from society for internships. But when to offer them is a big dilemma. At present, the most appropriate answer is to do it during the summer vacation.

Third obstacle

The third obstacle was the course length. For Turku, this was a minor problem, but for Nagaoka, this was a significant obstacle. Students from TUAS have to come to Japan in late August and have to return by early August of the following year. However, students from Nagaoka have to go to TUAS from late August and have to return by early June of the following year. To adjust for this discrepancy, Nagaoka KOSEN introduced a quarter system in the advanced course. Even with this adjustment, it remained difficult for Nagaoka students to take enough credits to complete the advanced course. That is because Nagaoka students can not finish enough credits and take about 5-months of internship within two years. Our solution was to extend the length of KOSEN's Advanced Course program from two years to three years for students enrolled in this double degree program (Figure 6).

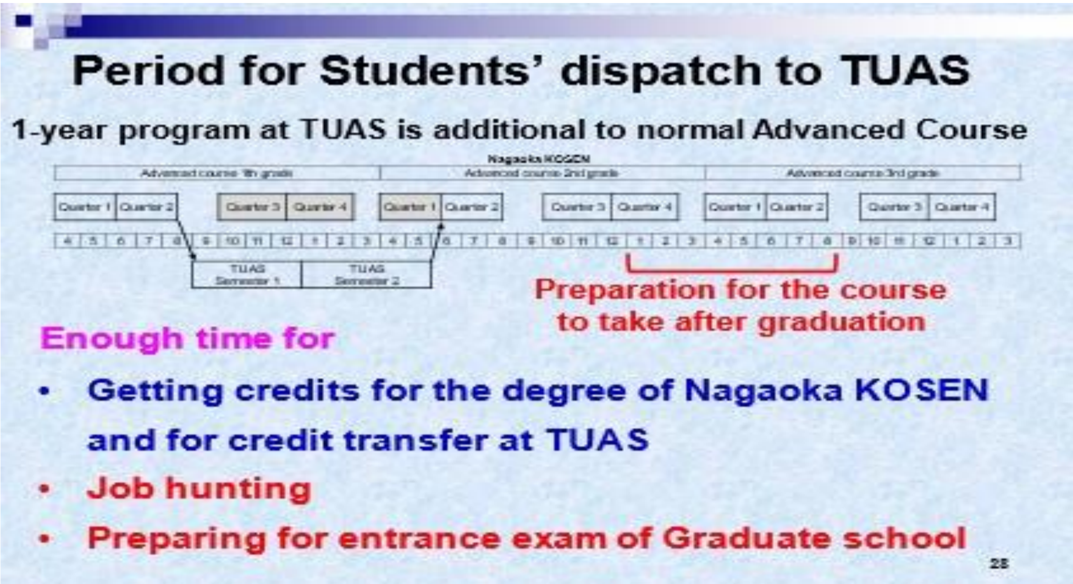

Figure 6. Prospect for Nagaoka students who obtain a double degree

Other obstacles

We still had other obstacles. One of them is the language. Although Nagaoka KOSEN accepts international students for short term acceptance, they usually study at seminars or research laboratories before coming to KOSEN. The language they use is mainly English. For long term acceptance, three years, they usually study in ordinary classrooms and labs. The language they use is Japanese. In the case of the double degree students from TUAS, we debated whether we should create new subjects or not. Fortunately, we were ready to offer new subjects for them.

Another obstacle is the matter of tuition fee. TUAS is a private university. For international students in many European countries, they do not have to pay tuition fees. But international students in Japan are expected to pay tuition fees. In order to adapt to this difference, as a special case, the double degree students' tuition is refunded as scholarships.

Regarding the complexities of living and studying abroad, it is not surprising that the double degree students from Nagaoka have high communication skills in English, high motivation for studying, and high basic academic skills.

Results and Discussion

In this paper, we introduced how we reached the double degree program's conclusion and what challenges we faced along the way. But this is based on the perspective of Nagaoka KOSEN. From the TUAS point of view, it may look very different.

For TUAS students, they study in Japan for one year and study in Finland for three years, they can graduate with a bachelor's degree from TUAS and a certificate from Nagaoka KOSEN (in a regular four year time span). However, the certificate is not accepted as a standard qualification in European countries.

On the other hand, Nagaoka students, they study in Finland for one year and study in Japan for four years, they can graduate with a bachelor's degree from TUAS and a bachelor's degree from National Institution for Academic Degrees and Quality Enhancement of Higher Education. The students who take this program graduate one year later than ordinary students.

Conclusions

We think that the main attractions of the double degree program are that students get the two bachelor's degrees, gain an international perspective, and develop business skills.

We finally reached an agreement in 2020, but this program is not perfect as we have discussed above. This program has just begun. In the near future we will probably find unexpected problems, and we have to overcome these problems together.

Acknowledgements

We would like to thank Dr. Motomu Takeshige, the previous president of Nagaoka KOSEN. We are grateful to the stuff of TUAS who are concerning this double degree agreement. We would also thank the member of the double degree working group at Nagaoka KOSEN.

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TEACHING OF JAPANESE LANGUAGE TO INTERNATIONAL STUDENTS BASED ON CDIO

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Abstract

What kind of Japanese language and communication skills are required for international students in engineering courses following the Conceive Design Implement Operate (CDIO) syllabus? How can engineering and language teachers effectively share a common view of proficiency levels of language in international students? To address these issues, this paper presents a progressive proficiency benchmark of Japanese language and communication skills required at technical colleges. This benchmark is developed based on the results of surveys conducted on faculty members and the framework produced by the Global Engineers Language Skills (GELS) project. Furthermore, it is argued that in addition to the framework of GELS, using a benchmark that embodies the circumstances of the introduction destination would help to fill the problematic gap between language specialists and engineering professionals in designing progressive courses for international students to learn an additional language.

Keywords: *Japanese language, Proficiency levels, Engineer, CDIO syllabus, International students*

Introduction

The National Institutes of Technology known as "KOSEN" for engineering education in Japan has traditionally accepted international students as third-year transfer students at the high school graduate stage. Since 2018, six KOSEN have accepted 15-year-old international students who had just graduated secondary school from Thailand. The curriculum in KOSEN, which offer 5-year courses, follows the Conceive Design Implement Operate (CDIO) syllabus. It is characterized by the placement of specialized science and engineering subjects that emphasize experiments and practical training from the first year. Their classes are primarily conducted in Japanese. Therefore, international students are required to possess knowledge of specialized subjects as well as Japanese language competence to understand the lectures and express what they have learned. The Japanese language competence of international students, however, is not very high at the time of admission, and teaching Japanese from the elementary stage is conducted simultaneously with other subjects after admission.

Recently, the number of international students obtaining secondary education in Japan has grown significantly, and research on their learning support has been actively conducted (Monbukagakusho, 2007; Saito et al., 2015; Sakai, 2018). However, it is difficult to say that enough knowledge has been accumulated to provide role models of learning for international students who are supposed to take specialized subjects in science and engineering from the lower grades as seen in KOSEN, and language support is required for learning the subject in Japanese.

The CDIO syllabus currently offers ten topics related to communication elements to engineering students. However, these topics include little practical guidance for international students to learn their engineering curricula in an additional language (Rinder et al., 2016). In this regard, taking English as an example, a framework called the Global Engineers Language Skills (GELS) framework was suggested as a resource to enable students to fulfill the topics listed in CDIO's Communications syllabus in additional languages (Rinder et al., 2016). Appendix 1 shows a section of the GELS framework (for the full version, see the Global Engineers' Language Skills (GELS) network, 2021). This framework, in which the language and communication requirements of engineers are mapped against the skills and proficiency levels (A1–C2) laid down by the Common European Framework of Reference for Language (CEFR), created by the Council of Europe, has been rewritten to suit the specific needs of engineers.

However, the GELS framework should not apply only for local students going out, but also for international students who come in, as international students should also be offered the opportunity to fulfill the course requirements of CDIOs in their additional language. Furthermore, the GELS framework does not focus on the individual cultural dimension of language and communication training, as its standpoint is language-neutral. In practical terms, international students who migrate to a country need to correspond to its individual cultural nuances.

The purpose of this paper is to introduce the idea of establishing a progressive proficiency benchmark of communication skills for engineers in the Japanese language, which applies the GELS framework to the Japanese context. The reason for using the GELS framework is that this framework alike CEFR has versatility regardless of language, as it is language-neutral. Based on this framework, we try to embody language and communication skills according to the individual cultural dimension. In addition, due to space limitations, it should be noted that this paper considers only speaking and writing as communication skills.

The remainder of this paper is organized as follows. The methods section outlines the process of surveying engineering teachers at colleges about international students' communication skills and the lacunae in the learning environment in which they join. The results section presents the basic findings from the surveys and the resultant benchmark (A2–B2) of Japanese language and communication skills. This is followed by a presentation of the relationship with the GELS framework. The concluding section describes the limitations of the resultant benchmark and outlines plans for future work.

Methods

The results of the questionnaire survey conducted on the faculty and staff of the above-mentioned six technical colleges indicate that the lack of Japanese language ability led to learning difficulties in science, mathematics, and specialized subjects (Kita, 2019). After receiving this report, two Japanese teachers interviewed two teachers in charge of science and mathematics classes, one assistant faculty member of science and mathematics, three teaching assistants, and two student tutors who support learning outside the class in two different colleges (December 2019) to identify the following:

- learning activities that are difficult for international students
- under what situations Japanese is required during class
- what needs to be done (or not be done) in Japanese including learning outside of class
- the degree of overall achievement in class tasks

Next, with reference to previous research such as the GELS framework, CEFR, and Japanese Language Program of Tokyo University of Foreign Studies Academic Japanese Can-do list (AJ Can-do list) by Tokyo University of Foreign Studies (2017), Japanese teachers debated on how to create the progressive proficiency benchmark of Japanese required for studying engineering courses.

As the purpose is to develop academic Japanese proficiency rather than general Japanese proficiency from the elementary stage, we mainly referred to the descriptions of A1–B2 in the AJ Can-do list. Along with that, we considered the contents of hearing, the interviewer's experience of teaching Japanese, and the description of the scenes and items shown in various existing teaching materials. Based on these criteria we shortlisted 144 candidates. Based on these candidates, for systematically extracting them, follow-up interviews were conducted with the members who participated in the previous hearing (December 2019). Thus, 149 items were selected.

Results

Appendices 2 and 3 present the parts of the resultant benchmark (A2–B2) of Japanese language and communication skills for engineers. It is intended to serve as a corollary to the GELS framework: the vertical axis (A1 – A2 – B1 – B2 – C1 – C2) represents progress in proficiency from "basic user" to "independent user" (Rinder et al., 2020), and the horizontal axis includes five broad communication skills: Listening, Reading, Spoken Interaction, Spoken Production, and Writing. Corresponding to this assessment grid, in our benchmark, the linguistic characteristics of Japanese and the linguistic materials required at each stage are specified to make it easier for teachers with varied expertise to have a common understanding of the linguistic requirements of the course, beyond their backgrounds in designing material for specific educational stages. Taking the characteristics of *Spoken production* (A2) and *Writing* (B2) as examples, as the kind of Japanese proficiency required in class activities of science and mathematics subjects, the following points were pointed out in the interview.

> *Spoken production* (A2)
> I can recite numbers (ex. integers, decimals, and fractions), and mathematical/chemical formulas (ex. $10x - 1/3 (y + 3) = 5$, C_2H_6O) aloud.
>
> *Writing* (B2)
> I can write the outline of the program I want to create in classes such as introductory programming.
>
> While forming an answer, I can explain my thoughts not only by listing the formulas in the middle but also by adding Japanese characters that show the role of the formula and the relationship with the formulas before and after it.

In other words, using both the GELS framework and our benchmark as resources for engineering and language teachers to agree upon the proficiency levels of language required for international students would help fill the problematic gap between language specialists and engineering professionals in designing progressive courses for international students cooperatively. In practical terms, when science and language experts discuss the language proficiency of international students, language materials are not the most important. This is because the interest of scientific experts lies in the extent to which they can use the available language materials in the learning activities conducted using them.

Conclusions

This paper presents the Japanese language and communication skills required for studying science and mathematics subjects in the first year of engineering courses at technical colleges using five practices: listening, reading, spoken interaction, spoken production, writing, levels of proficiency, and setting out goals of language action. This offers a framework to fill the gap between language specialists and engineering professionals in designing progressive courses for international students together. The limitation of this study is that the subjects covered here (math, science, computer literacy) are not enough to analyze potentially different language and communication needs in different modules of the engineering course. Furthermore, each description in the list should be validated in terms of the learners' actual learning activities.

Acknowledgments

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Appendices

Appendix 1. A section of the GELS framework (GELS network, 2021)

	A1	A2	B1	B2
Listening in face-to-face and digital scenarios *e.g. *numbers, equations, topic-specific vocabulary. key ICT terms,*	I can understand frequently encountered lexis for digital communication and my engineering field*. I can understand a message that includes this lexis.	I can listen out for important Information and understand enough of a speech to answer simple questions. I can understand simple instructions that use a wider range of lexis for digital communication and my engineering field*.	I can follow instructions from other engineers. I understand enough from spoken media e.g. radio/ TV/ lectures/ webinars to be able to summarise the main facts and figures, provided the topic is familiar to me.	I can understand extended, structured speech and can follow potentially complex arguments and counter-arguments about a topic in my engineering field. I can identify and refer to specific points made in another's speech.
Reading simple → complex texts	I can understand frequently encountered lexis for digital communication and my engineering field*. I can understand simple sentences that include this lexis.	I can read simple paragraphs and can infer meaning where necessary in more complex text. I can follow instructions given in simple everyday correspondence (e.g. a note, an instant message, an e-mail).	I can understand correspondence and recognise distinctive differences in register. I can scan and search in texts of different genres and learn from instructive texts on familiar engineering topics.	I can find the answers to specific questions in complex texts on topics within my engineering field. I can read popular science texts on a range of subjects and follow potentially complex arguments and counter-arguments.
Spoken interaction in face-to-face and digital scenarios	I can meet new people and respond to basic questions about myself and my studies/ work. I can ask basic, corresponding questions. I can recognise basic non-verbal cues.	I can exchange more detailed personal and professional information and can cope in brief, routine situations with my peers. I can inform others about common difficulties. I can articulate words clearly and use non-verbal cues to facilitate the interaction.	I can use a range of simple language to deal with formal and informal situations and suggest solutions. I can interact in a conversation and participate actively in meetings about my work. I can ask questions to develop the topic of conversation.	I can interact effectively on a range of topics within my engineering field and address specific problems. I can substantiate my opinions with evidence, negotiate with colleagues, lead meetings, and interact effectively to reach a consensus.
Spoken production pre-learnt → spontaneous speech in face-to-face and digital scenarios	I can present myself, my background, my engineering field, and my future plans. With practice, I can give simple instructions and read out numbers and frequently encountered equations from my engineering field.	I can use scripted language and frequently encountered lexis* from my engineering field to describe objects, experiences, observations, and plans. I can verbalise formulae and communicate data in simple language.	I can recount my current work and previous experiences in connected phrases. I can summarise information, present data and describe specific processes. I can create and deliver a presentation with visuals about a technical topic.	I can describe and give effective instructions about specific processes and methods within my engineering field. I can interpret data spontaneously and share my understanding precisely and concisely.
Writing individual & collaborative in synchronous and asynchronous scenarios	I can enter text and basic information in e.g. forms, login pages. I can compose texts with simple sentences about myself, my background, and my engineering field.	I can compose simple texts for my peers about routine occurrences at school/ work. I can describe common objects. I can make and respond to requests and suggestions using the conventions of e.g. instant messaging, social media, and e-mail.	I can compose definitions and descriptions, and produce simple, cohesive text to inform readers about topics in my engineering field. I can correspond/ interact using a neutral and formal register. I can use reference materials to improve my writing.	I can summarise and/or paraphrase texts about technical topics. I can (co-) write texts that are effectively structured. I can write about technical topics in both an informative style and a persuasive style. I can use the conventions of formal correspondence.

Appendix 2. Benchmark of Japanese language and communication skills for engineers (levels A2–B2, Spoken interaction/ production)

	A2	*B1*	*B2*
Spoken interaction	I can ask my teacher or friends to speak slowly or paraphrase it into simple phrases. I can ask my teachers and friends what I couldn't hear or understand about the lesson contents and the teacher's instructions, and I can only have a partial understanding of what I heard. I can answer when asked about my schedule. I can ask questions about my friends' schedules, lessons, and event schedules. *Situation* Classroom activities/dormitory life	I can ask my teachers and friends what I couldn't hear or understand about the lesson contents and the teacher's instructions, and I can understand most of what I heard. I can get the information I need by giving detailed information about functions, design, etc. to people who are familiar with the products, such as electronic dictionaries. I can check, give instructions, and receive details of the work to prepare for events such as school festivals with my classmates. *Situation*	I can ask my teachers and friends what I couldn't hear or understand about the lesson contents and the teacher's instructions, and I can understand almost all that I heard. After a brief introduction at my homestay, I will be able to answer questions on various topics such as the experience of learning Japanese, and plans during my stay in Japan, with hardships and aspirations. In the dormitory, I can clearly explain in detail to newcomers and juniors, and answer questions about

	Key features: *Word/phrase* Response/rejection expression/Hearing back/Paraphrasing to other expressions including English *Sentence* Please <Verb>. Could you <Verb>? [Preface to the request], [request]. I am going to <Verb>. <Noun> is that～. Would you like to <Verb>? Let's <Verb>. *Discourse* I can interact using a simple sentence.	Classroom activities/dormitory life *Key features:* *Word/phrase* I can interact using some spoken words, abbreviations (~ teru, ~ chau). I can interact using basic honorific expressions (~sareru, ~itasu, ~kudsaru, ~itadaku). I can ask and understand the meaning of unknown words and expressions. *Sentence* I can exchange not only simple sentences but also complex sentences. I can interact using sentences consisting of short modifiers, some abbreviations, premature sentences, and inverted sentences. *Discourse* I can express my impressions and opinions about the topic in one word or a short sentence. While listening to the other person's story, I can add aizuchi and filler to maintain the dialogue.	the procedures or tips of duty, points to be noted, etc. *Situation* Classroom activities/dormitory life/Extracurricular activities *Key features:* *Word/phrase* I can interact using most spoken words, abbreviations, and honorific expressions. *Sentence* I can interact using sentences consisting of long modifiers, most abbreviations, premature sentences, and inverted sentences. *Discourse* I can state my requirements while looking at the understanding of the other person without unilaterally stating them. I can correct the content of the story misunderstood by the other party. While listening to the other person's story, I can cooperate in searching for words, supplement them, and maintain dialogue.
Spoken production	I can make a simple presentation by arranging ideas linearly according to the content. If I have a problem, I can explain to my friends and teachers what is wrong and what I want to do with simple words and sentences. In group activities in class, I can explain my opinions and thoughts to classmates using simple words and sentences. I can also state whether I agree or disagree with the opinions of others. I can recite numbers (ex. integers, decimals, fractions) and mathematical/chemical formulas (ex. $10x - 1/3\ (y + 3) = 5$, C_2H_6O) aloud. *Situation* Classroom activities/dormitory life *Key features:* *Word/phrase* How to read numbers and mathematical/chemical formulas *Sentence*	I can use simple words and sentences to describe the people around me and myself. I can explain the features of familiar games such as sports to your friends in short and simple words while showing them those movements and diagrams. As a day duty in a dormitory or class, I can make clear, fluent, and natural announcements such as notes and urgent notices. *Situation* Classroom activities/dormitory life *Key features:* *Word/phrase* I can speak using demonstrative (this, it, that) properly. *Sentence* I can speak using connection expressions to make the development of the story easier to understand. I can speak using basic honorific expressions. *Discourse*	I can make presentations about people around and the content of the lesson according to the set time and format (introduction, body, and conclusion). If prepared in advance, I can objectively explain the facts such as graphs and charts about the results of experiments and surveys. I can tell my friends a cohesive story about the events and impressions of a cross-cultural experience. *Situation* Classroom activities/dormitory life *Key features:* *Word/phrase* I can use spoken expressions and written expressions properly. *Sentence* I can speak sentences consisting of academic expressions and long modifiers. *Discourse* I can make a presentation with a preface and annotations.

	～ be Noun / Adjective. I want to Verb. I think ～. *Discourse* 5W1H: When, where, who, what, how, why	I can make a presentation using the standard expression of the presentation.	

Appendix 3. The benchmark of Japanese language and communication skills for engineers (levels A2–B2, Writing)

	A2	*B1*	*B2*
Writing	I can write my personal data such as my name, school name, department, etc., or type it in with the keyboard. I can easily write events of a day or a certain period along the time axis. Also, I can easily express my impressions of the event (About 400–600 characters). *Situation* Classroom activities/dormitory life/Extracurricular activities *Key features:* *Word/phrase* Everyday life terms, time expressions, simple conjunction (but, and, then, in addition, for example) *Sentence* Compound sentences (~te, ~te) *Discourse* 5W1H: When, where, who, what, how, why	I can write sentences with a clear structure (introduction, body, and conclusion) about events in daily life and matters in your specialty (About 400–800 characters). If I can confirm it as needed, I can understand the questions in the survey about student life and write the answers. By exchanging SNS with friends, I can convey events and impressions of music and movies, etc. *Situation* Classroom activities/dormitory life/Extracurricular activities *Key features:* *Word/phrase* I can write the demonstratives (this, it, that) properly. I can add a heading that briefly describes the content. I can write using connection expressions to make the development of the story easier to understand. I can write down the words and phrases I hear in my mother tongue or Japanese. *Sentence* I can write using sentences consisting of short modifiers and complex sentences. *Discourse* I can write sentences with a clear structure (introduction, body, and conclusion). I can use the literary style at the end of the sentence properly. I can modify text based on the advice of others.	Ｉ can write an interview article that introduces club activities and dormitory activities in a newsletter (About 600–800 characters). I can write text to explain graphs and charts about the results of experiments and surveys. I can write a basic report according to the format. *Situation:* Classroom activities/dormitory life/Extracurricular activities *Key features:* *Word/phrase* I can use the literary style throughout the text properly. *Sentence* I can write sentences consisting of academic expressions and long modifiers. I can write properly the concord relationship that appears in a sentence. *Discourse* I can write the text with clear points for each paragraph and connections between paragraphs (facts and opinions, opinions of others and my own opinions, explanations and examples, results and causes, order, changes, definitions, etc.). I can write the outline of the program I want to create in classes such as introductory programming. In writing the answer, I can not only enumerate the formulas in the middle but also add Japanese (Suppose ~, therefore, etc.) that shows the role of the formula and the relationship before and after it.

Workshop descriptions

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Innovative Multidisciplinary Project Teams in Virtual Environments

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Abstract

Members of various project teams will increasingly innovate virtually in multidisciplinary and international teams. Innovation is based on communication being the most critical factor for project success because 20% of the projects are unsuccessful due to inefficient communication. Based on the earlier research it is known that cultural background and language skills of the project team members affect communication. Moreover, differences in virtual communication between industries exists.

While much is known about virtual project teams, research has not yet systematically examined how industries impact the competences required for communication. The focus of this workshop is on the communication competences needed in virtual and multicultural project environments. Both generic and industry specific competences are discussed.

The aim of this workshop was to share knowledge of the generic competences needed for successful multidisciplinary virtual projects. The main research question was: What are the future communication competences needed in virtual and multidisciplinary project teams? What are the competences future innovators are expected to master? How to integrate the development of these competences into learning processes? Methods of future studies were applied in this workshop and participants discussed future competence requirements using megatrend cards. Erasmus + funded Mupic-project was used as a case example of generic communication competences. Mupic is a project where master´s students from 4 European universities form multidisciplinary and multicultural project teams to solve R&D assignments from technology industry partners (Skoda Transport and Engel). Student teams include students from the field of engineering (industrial design), management, marketing and art. The project focuses on developing project management and virtual communication skills, including language and cultural understanding skills, of the students.

In this workshop the participants identified 3 most important future megatrends that will affect competence requirements in multidisciplinary virtual project teams. Megatrends and competences identified:

1. Culture of experimentation: need for the ability to change direction quickly and tolerate incompleteness increases
2. The collective power of the Internet will increase: competence to create a sense of community in virtual environments and enabling people to collaborate in an unprecedented way will be even more important
3. Creativity begets work and wellbeing: creating meaningful experiences becomes necessary in virtual teams

The results of this future oriented workshop need to be taken into further discussion on the curriculum level at HEIs to ensure that the students acquire the competences needed.

Keywords

virtual communication, virtual teams, project teams, multicultural teams, multidisciplinary team

DESIGNING A SERIOUS GAME TO FIT THE LEARNING OUTCOMES

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Abstract

The serious game has been introduced as an interactive educational tool for teaching and learning processes. It motivates and engages the students as well as provides constant feedback to students that help to form skills and knowledge. Although the serious game offers various benefits to support teaching and learning in a variety of contexts, designing a serious game scenario for a particular subject is still difficult. One main reason for that is the difficulty in finding the balance between entertainment components and the pedagogy (i.e. learning outcomes). The serious game needs to have a clear objective and an explicit pedagogy to influence learning. However, the serious game would also need to maintain the enjoyment and fun components. This workshop would discuss how to design a serious game that fits a particular learning outcome.

Keywords: *Design, Serious game, Learning outcome, Entertainment, Alignment, Game scenario, Game-based learning framework*

Overview of the Workshop

The recent emergence of the serious game has introduced the use of the game as an interactive educational gaming tool. This type of game is referred to as a serious game that can be used to support teaching and learning on specific knowledge to enhance problem-solving skills (Ma, Oikonomou, & Jain, 2011). The serious game involves non-entertainment elements, such as concepts of software engineering and data analytics, into game-environment (Liu, Alexandrova, & Nakajima, 2011). It serves as a pedagogical tool with a learning purpose. It has been used in many applications, including in education and training (Graafland, Schraagen, & Schijven, 2012; Johnson, Vilhjálmsson, & Marsella, 2005), healthcare (Garcia-Ruiz, Tashiro, Kapralos, & Martin, 2011), military applications (Lim & Jung, 2013), city planning (Gómez-Rodríguez, González-Moreno, Ramos-Valcárcel, & Vázquez-López, 2011) and computer programming (Coelho, Kato, Xavier, & Gonçalves, 2011; Muratet, Torguet, Jessel, & Viallet, 2009). According to a recent report, about 25% of the Global Fortune 500 companies, particularly from the Unites States, Britain and Germany, have already adopted serious games for their training (Loh, Sheng, & Ifenthaler, 2015).

Previous studies have identified the benefits of using a serious game in a variety of contexts for both young and old learners (Ma, Oikonomou, & Jain, 2011). The benefits include enhancing engagement, encouraging curiosity, increasing motivation, enabling self-monitoring, improving problem-solving and decision making (Knight, et al., 2010; Kumar, 2000; Ma, Oikonomou, & Jain, 2011; Rieber, 1996).

Apart from these benefits, designing a serious game is quite a challenging task. One main challenge is to balance between the entertainment components with the pedagogy components. For teaching and learning, the serious game would need to have a specific learning outcome (William, Rahim, Souza, Nugroho, & Fredericco, 2018). This learning outcome can then be translated into a clear objective, which then converted into the gameplay. The gameplay needs to be able to convey the learning objectives to the students. On the other hands, the game should not lose its enjoyment and fun components as well. These components include fantasy (Lepper & Cordova, 1992), challenge (Rouse III, 2010), choice (Grabinger, 1988), mechanism and playability (Wilson, Broadbent, McGrath, & Prescott, 2017). It would allow the students to engage and immerse the students into the game, which would eventually motive them to learn and achieve new skills and knowledge.

This workshop aims to provide the participants with a few guidelines about the serious game and how it can be used in teaching and learning. Hands-on activities to design a serious game that fits a particular learning outcome based on the participants' intended subjects will also be conducted. The activities follow the principles in game-based learning framework as illustrated in Figure 1 (William, Rahim, Souza, Nugroho, & Fredericco, 2018; William, Rahim, Wu, & Souza, 2019). In the framework, a specific learning outcome will be converted into a particular scenario with clear goals for the students. The entertainment components are captured by the game characteristics (i.e. challenge, competition and fantasy) that allow the students to be involved and engaged in the game.

At the end of the workshop, a few successful examples of designing serious games will be reviewed. These games include a board-games as well as a digital game. Effectiveness of these games will also be discussed.

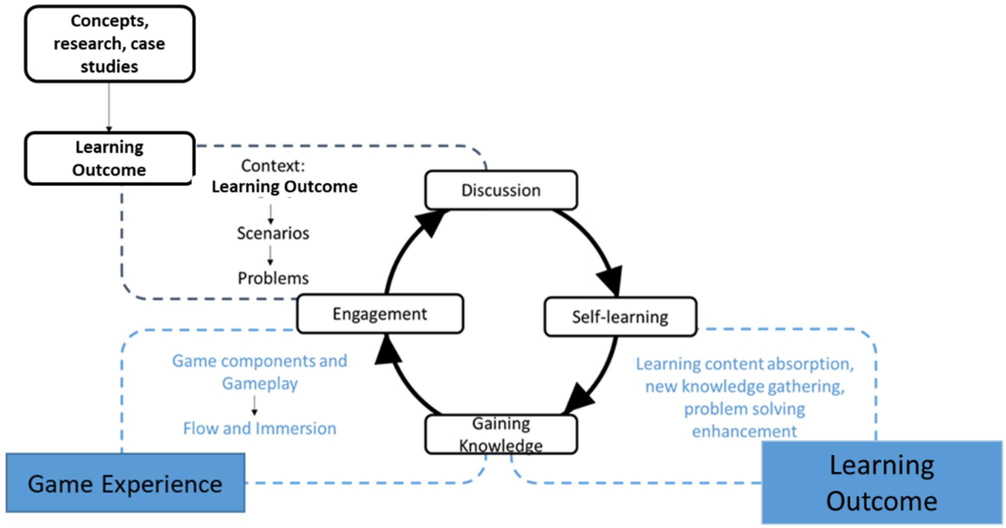

Figure 1. Game Design Framework (William, Rahim, Souza, Nugroho, & Fredericco, 2018; William, Rahim, Wu, & Souza, 2019)

Activities

In the workshop, the participants will be introduced to the serious game concept and the serious game design framework. Hands-on activities to design a serious game will be conducted. The activities include:

1. Selecting a subject for the serious game,
2. Identifying the learning outcome of the subject for the serious game,
3. Listing the game objectives,
4. Brainstorming the scenarios based on the game objectives, and
5. Designing a game scenario.

At the end of the workshop, a few examples of serious games used in particular subjects will be presented. Design consideration, as well as the effectiveness of the game, will also be discussed.

Target Audience

This workshop is suitable for lecturers or education practitioners who want to develop a serious game for his/her subject or who want to include gamification as part of his/her teaching and learning activities.

Outcomes

After attending this session, the participants would be able to understand the serious game and how to implement a serious game in the teaching and learning activities. Participants would also have an idea on how to design a serious game to fit the subject's learning objective.

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EMPOWERING FEMALE STUDENTS IN ENGINEERING: A STUDY ABROAD CAPACITY BUILDING INITIATIVE

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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 are female. Referred to as 'a leaky pipeline' (UNESCO 2015) this number decreases at doctoral level and drops more drastically when it comes to female researchers. To change the situation, female students in some National Colleges of Technology in Japan (KOSEN) have been volunteering at local schools to teach programming to younger generations, and female pupils in particular. Their goals are to foster interest in STEM and introduce children early to female role models. In this workshop, we share reflections on a study abroad capacity building initiative undertaken in the UK (2018). It was designed to support these female students undertake their volunteering work; to build capacity of female in language and communication skills, leadership, and teaching ICT skills to children.

Keywords: *Female empowerment, STEM, study abroad, capacity building, volunteering*

Overview of the Workshop

The purposes of this workshop are twofold: i) to share the reality of gender equality in STEM with conference delegates from different disciplines and countries and ii) to discuss the possibility of working together on ways to empower female students in STEM in the future, especially in international settings.

In Japan, the proportion of female students in STEM is low, particularly in Engineering. According to *the White Paper on Gender Equality 2019* published by the Japanese government, female students account for only 15% of undergraduate engineering students. Often referred to as 'a leaky pipeline' (UNESCO 2015) this number decreases at doctoral level and drops more drastically when it comes to female researchers. To change the situation, female students in some of KOSEN in Japan have been working as volunteers to increase the number of female students who enter their college. Volunteering, as McFadden and Smeaton (2017) suggest, will lead to student learning. It follows that higher education should provide students with opportunities to help others voluntarily (Ito, 2011; Ngo, 2014; Oie, 2017, Sakane, 2006). In the project discussed in this workshop, students volunteer at local elementary and junior high schools to teach programming skills to younger generations, and female pupils in particular. Their goal in volunteering is to foster interest in STEM and to introduce children early on to female role models.

In this workshop, we will share some reflections from a study abroad capacity building initiative undertaken in the UK in 2018 which was designed to support these female students in their volunteering projects. Embedded in understandings of global connectivity and mobility, study abroad initiatives are designed to offer intercultural educational experiences (Kinginger, 2009). It is important for education institutions whose goals are to prepare their students and staff for global workplaces to acknowledge that such workplaces are likely to be negotiated through a lingua franca, and within a context which is multinational, plurilingual and far from homogenous (Canagarajah, 2007). With an evaluative approach to study abroad experiences, students and staff can become active 'space navigators (Jang, 2020:171) who are aware of the importance of intercultural communication, diverse language speakers and language repertories. The 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 KOSEN 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.

During this interactive workshop, the contributors will facilitate participants' understanding of policy on gender issues in Japan; provide details of the study abroad initiative; engage participants in discussion on how the programme contributed to the empowerment of female students; and consider future collaboration for the capacity building of future innovators from different disciplines and countries.

Activities

The workshop will combine short presentations, task-based activities, and group discussions delivered and facilitated by the authors. During the 60 min session, participants will be introduced to the project members and the key issues to be addressed in the workshop. Participants will be supported to introduce themselves and to communicate their interest/experience in the topic. This is a key activity for the workshop and will enable opportunities for participants to collaborate in the future. The outline programme is as follows:

i) An overview of policy on gender issues in Japan
ii) The *Robogals* Project
iii) The UK study abroad initiative: activity, learning, and impact
iv) Group discussion
v) Conclusion

Target Audience

This workshop is designed for those who wish to raise their awareness of policy on gender issues in Japan; to learn more about a volunteering project undertaken by female undergraduate engineering KOSEN students working to increase the number of female students who enter their college; to learn about a study-abroad initiative undertaken in the UK (2018) which was designed to support the development of the female volunteers leadership, communication and teaching skills and to discuss the possibility of working together on ways to empower female students in STEM in the future.

Therefore, the workshop is intended for those who wish to know more about and/or wish to establish gender empowerment initiatives, or for those who are currently involved in gender empowerment initiatives. No previous experience, preparation, or background knowledge is required for participation in the workshop.

Outcomes

By the end of the workshop the participants will have:

i) an understanding of policy on gender issues in Japan
ii) knowledge of study-abroad initiative designed to support female students in their volunteering projects
iii) insight on how the initiative contributed to the empowerment of female students
iv) opportunities for future collaboration on similar projects in different disciplines and countries.

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Important Notice

We would like to make the most of this great opportunity to connect with international researchers and educators. At the end of the workshop participants can indicate if they wish to receive information about furthering connections.

BUILDING A PROACTIVE, COLLABORATIVE AND REFLECTIVE ACTIVE LEARNING ENVIRONMENT

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Abstract

Active learning has been commonly infused into lessons to promote learning for students. Active learning engages students with the learning content through activities that promote higher-order thinking and often involves group work (Freeman et al., 2014). We identify three key behaviours that students should have for them to be effective active learners, namely Proactive, Collaborative and Reflective. In this workshop, participants will learn how Republic Polytechnic's Problem-Based Learning environment inculcate proactive, collaborative and reflective behaviours in students. Participants will also work in teams to gain insights and to generate new ideas of inculcating these behaviours in different active learning environments. Other behaviours in students that can lead to effective active learning can also be explored.

Keywords: *Active Learning, Proactive, Collaborative, Reflective*

Overview of the Workshop

Active learning has been commonly infused into lessons to promote learning for students. Active learning engages students with the learning content through any activities to promote higher-order thinking and often involves group work (Freeman et al., 2014). Strategies and examples of active learning activities include peer teaching activities, game-based learning platforms, rotating chair group discussions (Raudys, 2018). The duration of the activities is also important to grab the attention span of students (Lang, 2016).

There are three key behaviours that students should have for them to be effective active learners. Firstly, since active learning is learner-centered, students should be proactive. Proactive students take responsibility of their learning. Instead of receiving information from their teacher passively, they take the initiative to do things better, to make the best possible decisions, and to solve problems.

Secondly, students should be collaborative in active learning as they learn through collaboration and interaction with other students. Collaborative students are team workers who listen to and seek to understand the feelings, concerns, opinions, and ideas of others. They can be team leaders or team players.

Thirdly, they should be reflective. Students who are reflective constantly look back at their learning and the work they have done, and constantly find ways to improve themselves. They learn from every experience or situation that they encounter, including mistakes that they made.

This workshop is set to explore how to build learning environment to inculcate proactive, collaborative, and reflective behaviours in active learners.

Activities

Based on a 60-minute workshop, Table 1 shows an outline of the proposed activities of the workshop.

Table 1: Workshop Outline

Activity	Length
Defining Active Learning	5 min
Describing Proactive, Collaborative and Reflective Behaviours for Effective Active Learning	5 min
Sharing of Republic Polytechnic's Proactive, Collaborative and Reflective Problem-Based Learning Environment	10 min
Team Activity	20 min
Team Presentation	15 min
Conclusion	5 min

The workshop will begin with the facilitator giving a brief description of active learning. This is followed by explaining the need to inculcate proactive, collaborative, and reflective behaviours in active learners to make learning more effective, which include a summary of related work of Baldwin and Chang (2007), Gibbs (1998), Laal and Ghodsi (2012), and Pappas (2019).

Active learning environment can be tuned to help learners to inculcate these three behaviours. Republic Polytechnic's Proactive, Collaborative and Reflective Problem-Based Learning environment is used as an example to set the stage for the team activity of this workshop. Within each team, members will share ways and explore new ideas on how to infuse Proactive, Collaborative and Reflective behaviours in the active learning environments of their institutions. During the team presentation segment, the teams will present their work, and will share and reflect on how proactive, collaborative and reflective behaviours have also been advocated within themselves during the team activity to promotion active learning.

The workshop will conclude with a summary of ideas and findings generated, and possibly leading to suggestions for future work in the area.

Target Audience

No background knowledge or preparation is required for participants to attend this workshop.

Outcomes

This workshop is intended to share good practices and to generate new ideas on how Proactive, Collaborative and Reflective behaviours can be inculcate in active learners via their learning environment. Other behaviours in students that can lead to effective active learning, if any, can also be explored to be infused in the learning environment.

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Design of the Diverse Exchanges between Various Students using Engineering as a Common Language

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Abstract

What should teachers prepare for better discussions with students? It is important to speak and interact with English as a common language to encourage international and versatile interaction. Our students have another common denominator, learning Engineering. We will discuss teacher preparation in this workshop to encourage interaction and discussion among students. It will bring better benefits to themselves.

In the beginning of the workshop, we will share our students' tendencies towards discussions and try to get an idea of the variety of students envisioned. After that, we point out the factors that make it difficult for students to discuss. The next step is to come up with ideas about what kind of leads are good for students to discuss the significance and fun of learning engineering. Through these phases, we will find out what preparations are effective for us, teachers to succeed in the discussion.

Keywords: *Engineering education, discussion, exchange, culture, common language, class preparation, diversity*

Overview of the Workshop

In the current global situation, students will work everywhere in the world and have to achieve results in a variety of situations, especially engineering students who are needed everywhere because of their usefulness. Getting and accumulating some experiences before they start working will be a good training for them and have synergistic effects on their learning and research. So teachers need to design the opportunity of diverse exchange for engineering students. Similarly, teachers also must have a variety of interactions. Therefore, this workshop proposes the discussion about designing opportunities for students to interact independently.

This workshop will discuss what essence teachers need to support students from diverse backgrounds discussing and interacting with engineering as a common language. Therefore, the process of this workshop is very simple.

Participants will be divided into four groups which are four to six members (maximum 6 persons) for discussion. Participants are divided into tables in advance by the organizer. All participants including organizers will share the current situation by short presenting the worries of the organizer and participants and the trends of students. The organizer has not yet been determined that short speakers may be set by the organizer or may be invited by the participants to share that. In classroom discussions, faculty members face a variety of situations and difficulties, such as stagnation, lack of opinion, student independence, and discussion topic setting. Also, this workshop is intended to include non-native English speakers or second language students. This step shares their status quo and creates a common understanding in this workshop.

The organizer will present the points of the discussion as part of the next discussion process. The following discussion topics are presented to the group of participants.

1) Motivation for student discussion
2) Idea of trigger to bring out utterance
3) Notes and ideas for setting topics related to engineering
4) Promoting participation in English discussions

Each group will share ideas and exchange ideas based on their rich experience and good communication. Also, the organizer may provide some keywords for discussion.

As the final step, each group tries to create ideas of the materials, topics and practicing for the preparation by teachers before class. Participants discuss what and how to prepare teaching materials based on each group theme. Setting the discussion theme is similar. However, the most important thing is what kind of training the teacher should do mentally and inspiring students by speaking.

Activities

The activities in this workshop are very simple as shown in the following figure 1.

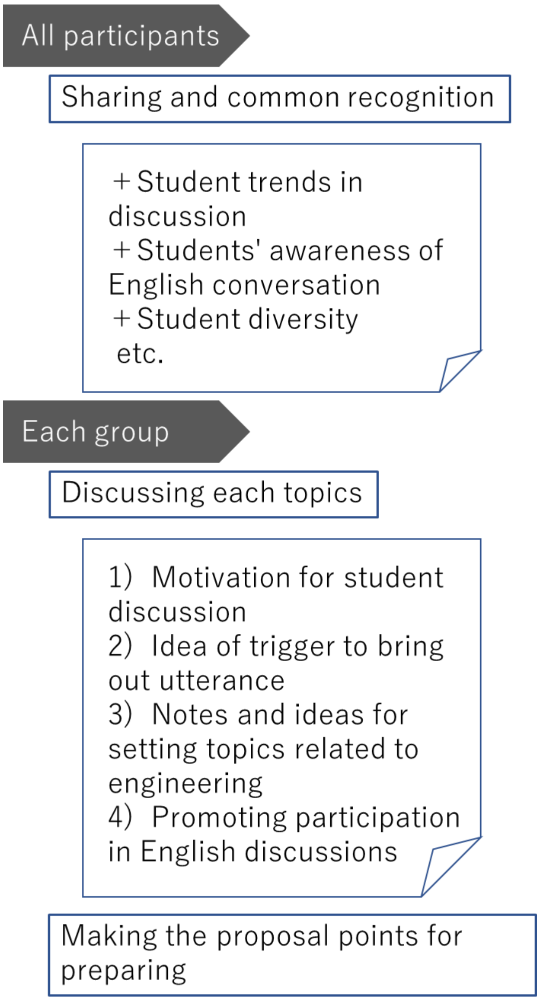

Figure 1. Process image

Finally, each discussion results may share for all by quick presenting or presenting a table of discussion at the end of the workshop session.

Target Audience and Outcomes

We are targeting all teachers and faculty members in this workshop. May be helpful if participants are wondering how student discussions proceed. If your students are hesitant to speak English, participants may find hints. If we want our students to be able to deepen their discussions and interactions through engineering, the discussions in this workshop may be interesting. Let's discuss together so that our students can deepen their discussion and interaction through engineering. In addition, it will be beneficial and inspiring for students with diverse backgrounds and majors to speak on the table together.

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CHALLENGES IN EMBEDDING SUSTAINABLE DEVELOPMENT IN ENGINEERING EDUCATION

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Abstract

Education should provide students with knowledge, skills and motivation, which help them to act in changing society developing it towards a sustainable future. The sustainability crisis needs to be taken into account in education development: how education should react and ensure competences and attitudes in order to solve the crisis and build a sustainable future.

In Finland, higher education institutions have recently published their programmes to advance sustainable development (SD) in education. These programmes cover the promises how to embed sustainability in education. Additionally, the CDIO framework for engineering education has added an optional standard to contribute to a sustainable development as a key competence.

In this workshop, we first introduce the practical steps in embedding SD in education at Turku University of Applied Sciences (TUAS) in Finland. The purpose of this interactive workshop is to discuss the challenges and share best practices to embed SD in engineering education.

Keywords: *sustainable development, engineering education, education development, CDIO, change management*

Overview of the Workshop

There is a need for a quick change in education. At present, education is not able to adequately react on the sustainability crisis taking place all around us. Education should provide our students with knowledge, skills and competences as well as develop attitudes and values, which help them to act in changing work and society bringing them towards sustainable future. The impacts of sustainability crisis are often ignored in the discussion on education development: how education should react and ensure competences and attitudes in order to mitigate them.

In Finland, higher education institutions, both universities and universities of applied sciences, got down to business at the end of year 2020 and published their programmes to advance SD in education. These programmes cover the promises and practical steps how to embed sustainability issues in education. The topics which are covered are especially how to foster sustainable development (so called handprint):

- in all study fields and programmes, and which contents should be covered, and how learning best takes place,
- how SD can be integrated in RDI actions of the university
- how SD is implemented in university management and staff development

and

- how to mitigate carbon emissions and diminish environmental impacts of university actions (so called footprint)

Additionally, the CDIO framework for engineering education has added the optional standard for engineering education add SD as a key competence for students. At TUAS the CDIO framework is applied to both engineering and business students.

In this workshop we will hear first a short overview of SD programme at TUAS and how it is implemented. We will also briefly discuss how CDIO optional standard on sustainable development is seen and implemented at TUAS in the department of Engineering and Business.

After the overview, we will focus on challenges and best practices how to integrate SD in studies and other activities in different educational institutions providing engineering education. The aim is to learn from each other, create shared understanding and encourage us to work together towards that how we can genuinely connect SD to education.

Activities

Introductory session will take about 15 minutes. After that we will present some guiding questions and lead the participants to smaller groups to discuss these questions for 20 minutes.

After the team work session each group will introduce their ideas and comments. A joint debate will be conducted, and final conclusions drawn.

The workshop will take max. 60 minutes altogether.

Target Audience

Everyone being interested in education development and how to embed sustainable development in education can attend this workshop. There is no specific background knowledge required for participants, but it is useful to get acquainted with basic concepts of SD in advance (see the references), as well be prepared to tell how the topic is seen in one's own institution.

Outcomes

The anticipated outcomes of the workshop are the following

- to learn from each other
- share best practices
- create shared understanding
- encourage educators to work together towards that how to genuinely connect SD to engineering education

Results

The workshop was well planned and organized. There were also 5 TUAS students involved, 4 of them prepared to act as assistants in discussion groups and one as a technical support. However, there were not many participants. Still, the workshop was conducted as planned, and the discussion was kept up with help of students.

The topic of sustainable development is maybe still evolving in engineering education.

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Credit-Bearing Student Exchange with Blended Learning

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Abstract

Student exchange programme can be either credit-bearing or non-credit-bearing. The former which requires curriculum development / collaboration with the partner institute prior to the commencement of the exchange programme brings more benefits to students than the latter does. Under the Quality Assurance System of Vocational Training Council (VTC) – Hong Kong, credit-bearing programme should satisfy the requirements of Qualifications Framework with several VPET elements, for instance, resources implications, teaching staff qualifications and experience, intended learning outcomes, teaching and learning strategy, assessment scheme, etc. Student exchange which becomes more popular nowadays benefits students by understanding the latest development of the industry and their practices through industrial visits in the host country. Besides knowledge and skills of the programme, students can learn other cultures, improve their language skills, make friends of the same trade and broaden their social horizons.

To make student exchange more flexible and effective, blended learning is employed to combine both face-to-face and online learning, through a series of online educational materials and interactive activities. For instance, (i) before departing for the host institute, students of both sides can be briefed online the programme objectives and get to know one another. (ii) When they arrive at the host institute, both can study together and interact with each other by doing mini-projects in groups. (iii) After returning, they can report what they do in the project for assessment. Furthermore, students are enhanced with more international values through cultural projects and thus making friends.

Recently, the global pandemic has restricted in physically travelling abroad and has adversely affected many internationalisation activities. In view of this, special arrangement should be implemented to suspend the face-to-face class. The second part (ii) of the exchange programme should go online. The exchange programme turns out to be 100% virtual. In this regard, it does not necessarily require students to study outside their home country, instead it allows internationalisation happening locally.

Keywords: *credit-bearing, qualifications framework, student exchange, blended learning, internationalisation happening locally*

Overview of the Workshop

Engineering Discipline of VTC has collaborated with five vocational institutes in Sichuan, China, for five common vocational modules in respective areas. In view of this, the Engineering Discipline is going to implement the exchange programmes.

In this workshop, participants will be split into groups to discuss how to implement the credit-bearing exchange programmes with different parameters of class arrangement, blend learning mode, etc.

Activities

A practice sharing by the facilitator(s) for 15 minutes followed by group discussion for 20 minutes in various chat rooms. 15 minutes presentation session will be given by the selected groups A wrap-up at the end of the workshop will be followed.

Target Audience

The workshop is custom-made for teaching staff and administrative officers who work for internationalisation, curriculum collaboration with overseas partners.

Outcomes

During the workshop, the experience on the implementation of credit-bearing exchange programmes was shared. Further discussion among the groups was made for exchanging ideas on the topic in different countries.

After the workshop, the participants realise the benefits of the fusion of student exchange and credit-bearing that can provide more in-depth understanding of industry development of the host country; and learning different ways of thinking from others. Furthermore, the participants can appreciate others' experience in teaching and learning for internationalisation with the fellows who are from other countries.

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INCORPORATING PROJECT-BASED LEARNING INTO ENGINEERING CURRICULUM

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Abstract

Learning is a process to acquire new knowledge, skills and understandings of a subject by experience, by studying it or by being taught. Teacher-centered teaching is the conventional way for facilitating students to learn that the teacher is in-charge of the whole learning process, and acts as the sole supplier of knowledge to deliver the lesson under the teaching plan. However, some researches find that it is more effective if learning is student-driven instead of driving by the teacher.

Project-Based Learning (PBL) is a contemporary student-centred pedagogy. It allows students to learn a subject or a series of subjects by working on a project for an extended period of time to investigate and respond to a complex questioning, challenge or a problem. There are 7 essential elements in designing a project in order to ensure the effective implementation of PBL.

Keywords: *Project Based Learning, Contemporary Pedagogy, Learning Outcomes, Student-Centred, Gold Standard*

Overview of the Workshop

Through PBL, students can be motivated through working as a group on a project. In this regard, students are actively engaged in doing a challenging and authentic project. They are required to solve a series of problems that are important and realistic by sustained and collaborative real-life investigations. The pedagogy leads to deeper understanding and greater retention of content knowledge, which facilitates students to apply what they have learnt in new situations.

In view of this, the Engineering Discipline of VTC is going to implement PBL into the curriculum to engage students in the learning process, that can raise attainment and promote deeper learning and integrate authentic problems with content knowledge and applied skills.

In this workshop, participants will be split into groups to discuss how the PBL pedagogy and assessment can be implemented through examples at post-secondary level engineering programmes to achieve the original intended learning outcomes of the module. The participants will be facilitated to have an overview of incorporating PBL into the curriculum and anticipating any difficulties in the implementation. Based on some cases and experience sharing, participants can share their views and experience to give an insight for continuous improvement.

Activities

In the workshop, it is mainly a group activity. An introduction of PBL and the practice of VTC with examples will be shared. The participants will then be split into a few groups each of which will have 15 minutes to discuss the pros and cons of using PBL as the pedagogy for teaching and learning and finally come up with some solutions / recommendations. Representatives from the groups will present the discussion results in 10 minutes.

In the second part of the workshop, the activity is repeated that the groups will be assigned to discuss in 10 minutes about the pedagogy which is used to boost students' motivation and learning efficiency during their teaching. After that, representatives from the groups will present the discussion results for another 10 minutes.

Finally, the workshop is wrapped up with conclusions in 5 minutes.

Target Audience

Everyone who would like to share their ideas and experiences on teaching and learning by using different pedagogies.

Outcomes

During the workshop, the experience on the implementation of PBL into the VTC Engineering curriculum was shared, further discussion has been made for exchanging ideas on the incorporation of the pedagogy.

After the workshop, the participants are able to identify the pros and cons of using the PBL pedagogy for teaching and learning. Furthermore, the participants continue to share their precious experience in teaching with the fellows from other countries.

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