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Abstract

The current study is in response to mitigating challenges faced by Japanese beginning teachers of the Technology education (TE) subject when achieving the aims of the revised national curriculum for Technology Education and the proposed *The New Framework of Technology and Engineering Education for Creating a Next Generation Learning*. This research aims to clarify the key factors required to create support structures through junior high school and university collaboration, empowering beginning TE teachers to implement design-based learning in their school technology curricula. This study applied a qualitative inquiry strategy based on the principle of purposeful sampling to create a single significant case study. This case study will use a self-study approach as the purposeful sampling strategy. The self-study is based on a collaborative design-based project that the authors have worked together and implemented in the technology lessons in the academic year 2023. The design-based project was placed in the second semester of the TE curriculum for 2nd-grade students. The duration of the project was planned for eight lessons. This project would focus mainly on topics related to biological technology, but at the same time, integrate other key learning content such as material and processing, design process, science, and mathematics. The theme of the project is called Kitchen Farm. In this project, students worked in groups of about 5-6. Three classes of 2nd-grade students went through the Kitchen Farm project. The object of study is mainly based on the qualitative data collected from the teacher's reflection (which is the second author) after the implementation of the project. Based on the content of the teacher's reflections as findings, the data is analyzed by the first author to elucidate meanings. Through this study, four key factors are suggested to be necessary for considerations to create support structures to empower beginning TE teachers to be able to plan and implement design-based learning were clarified: 1) professional development for design-based learning, 2) developing necessary teaching and learning strategies, 3) preparations of learning environment, and 4) creating opportunities for consultation and support through universities and cluster schools.

Keywords: *design-based learning*, *curriculum planning*, *design thinking*, *teacher development*

1. Introduction

Technology Education (TE) in Japan is a general education subject offered in the junior high school curriculum. The current national curriculum for TE in Japan was revised in 2017. As part of the objectives in the national curriculum for TE, summarized by Moriyama et al. (2024), students are to be developed with complex problem-solving competencies such as identifying problems in daily life settings, understanding the problem through research and inquiry, ideation to explore creative solutions, and creating prototypes to experiment and evaluate solutions for their effectiveness to solve the problems. The learning content in the current TE curriculum can

be divided into four main areas: A) *Materials and Processing Technology*, B) *Biological Technology*, C) *Energy Conversion*, and D) *Information Technology* (Moriyama et al., 2024).

As part of a review of the current status of students' learning in TE in Japan, Moriyama et al. (2024) found that the required students' complex problem-solving competencies are not well developed through the current design-based learning activities in the classrooms. It is possible that design-based activities, in general, may be limited to activities that mainly work on selecting and improving solutions prepared by TE teachers. Thus, students are slightly weak in linking their learning to social issues. Current problem-solving activities in TE classrooms are not able to sufficiently engage students in activities related to inquiry, experimentation, and observation. Moreover, current problem-solving activities offer limited design-based activities, which possibly impact students' ability to evaluate, select, manage, and operate technology and the ability to improve and apply technology to create new value in society.

As part of the reform to the current technology education, The *New Framework of Technology and Engineering Education for Creating a Next Generation Learning* (NGTE) is developed by the Japan Society of Technology Education (JSTE) (Moriyama et al., 2024). As part of the review of this framework, it is mentioned that reformation of teacher education and training is required if TE in Japan is to develop a new generation of students that possess the competencies to solve complex problems through the engineering design process. As part of teacher development, this study advocates that collaboration between university academics and TE teachers on the ground is crucial to support and upskill TE teachers to implement meaningful design-based activities in their classrooms. As such, the current study is in response to mitigating challenges faced by Japanese beginning TE teachers when achieving the aims of the revised national curriculum for TE and the proposed NGTE. This research aims to clarify the key factors required to create support structures through junior high school and university collaboration, empowering beginning TE teachers to implement design-based learning in their school technology curricula.

2. Literature Reviews

2.1. Proposed changes to current Japanese TE national curriculum and the implications to teacher development

The current national curriculum for Japanese TE in junior high schools was reformed in 2017 and was fully implemented across Japan in 2021. As a form of general education, students at the age of 13 to 15 (Grade 7 to 9) study TE as a compulsory subject. The number of lessons for each year is allocated as such: 35 lessons each year for Grade 7 and Grade 8, and 17.5 lessons for Grade 9. Each lesson is 50 mins. As part of the reform, the current TE curriculum emphasizes solving problems in daily life and society through technology. The learning content in each of the four main areas, as mentioned previously, is developed around three key considerations: 1) technology that supports daily lives and society, 2) problem-solving through technology, and 3) technology and the development of society (Furukawa, 2017). The learning process in TE is also organized in an iterative problem-solving process that involves problem finding, designing and developing solutions based on the understanding and application of technology, realizing the ideas into prototypes, evaluating solutions, tackling the next problem, and so on.

The JSTE has been involved in leading academic research and developing TE in Japan. JSTE has also been involved in the previous iterations of the Japanese TE national curriculum. With the mission to move Japanese TE forward beyond the current TE national curriculum, JSTE took the lead in proposing NGTE in 2021. In the NGTE, the iterative process of design is clearly articulated through the Triple Loop Model of the Engineering Process (hereby called the Triple Loop Model in this paper) (Moriyama et al., 2024). In the Triple Loop Model, students' learning process will be clearly defined through the needs-finding and understanding of the problem

(Needs Exploration Loop), ideating and developing appropriate solutions to solve the problem by applying technology (Seeds Exploration Loop), and realizing, evaluating and improving the solutions (Creation Loop). The NGTE can be seen as a significant reform where the current Japanese TE will transform into a more design-based learning subject than previous versions. The implications for current Japanese TE teachers will be the need to be acclimatized to teaching and facilitating design-based learning in the everyday teaching of TE in Japanese junior high schools.

2.2. Nurturing a Japanese TE teacher

The training of Japanese TE teachers is well summarized by Miyakawa (2020). TE teachers are mainly trained in Japanese national universities that offer TE teacher education in the departments of teacher education and teacher colleges. In comparison, some TE teachers may be trained in the engineering and agricultural departments in national and private universities. The university programs to train TE teachers offer the study of credits for all necessary subjects based on the Educational Personnel Certificate Law. Miyakawa (2020) highlighted several issues that national universities and teacher colleges faced, which resulted in students' studying specialized fields that were often broad but shallow. As such, students usually do not have a deep understanding of the content of the specialized fields related to TE. On the contrary, prospective TE teachers who studied in the engineering and agricultural departments are generally well-trained in specific specialized fields but shallow in other TE-related fields. Prospective TE teachers need to complete the TE teacher education programs for four years and obtain a bachelor's degree. In addition, teachers also need to obtain a teacher certificate granted by the prefectural board of education in accordance with the Educational Personnel Certification Law established by the country.

A review of the content of the programs offered by Japanese national universities and teacher colleges that educate TE teachers will provide a glimpse of the knowledge and skills TE teachers are trained in. As the education system in Japan is relatively uniform, the content offered by the programs for educating students to become TE teachers is generally similar. In general, university programs for TE teacher education consist of Common Subjects and Professional educational Subjects. Common subjects consist of liberal arts, information studies, foreign languages, and sports. Professional education subjects consist of common professional education subjects and course majors that consist of subjects to study specialized fields related to TE. The study of subjects in course majors and obtaining the required credits is a prerequisite for obtaining the teacher certificate based on the Educational Personnel Certification Law. The course major subjects are organized into six areas: 1) Woodworking, 2) Metalworking, 3) Machines, 4) Electricity, 5) Cultivation, and 6) Information and computers. Other subjects, just to state a few, related to TE include the study of the history of TE, administration, educational technology, teaching materials, pedagogies, educational psychology, instructional planning, assessment methods, learning environment management, etc. A review of the content of the TE teacher certification test reference materials created by JSTE shows that there is very little content related to design-based learning. Thus, content on design-based learning is not much covered in the TE teacher training programs offered by the universities.

Professional development largely depends on the TE teacher's interest and motivation. Currently, JSTE constantly plans professional development events that help promote the professional development of TE teachers. At the same time, individual university academics also took up the roles of instructors to offer in-service professional training to TE teachers. Professional development primarily lies on individual TE teachers; few literatures have offered a systematic approach to upskilling TE teachers on a large-scale basis when the national curriculum changes.

2.3. Overseas teacher education for Technology subject at junior high school

Design and Technology (D&T) is a general education subject offered in overseas secondary education, such as Singapore and Australia. D&T is similar to TE but incorporates a much heavier presence of design-based learning content. Puddicombe and Williams (2020) provided an

overview of Australian universities offering programs for D&T teacher education in Australia. A scan of some of the bachelor's degree programs offered by some of the Australian universities mentioned by Puddicombe and Williams (2020) and those listed on the website of the Design and Technology Teachers Association, Australia (DATTA) discovered that the study of design-related subjects can be found in the curricula. Such subjects are Design Principles, Design Fundamentals, Product Design, Design Innovations, Design workshops, Design Thinking, Design in materials (such as timber, metal, textiles), etc. In Singapore, there are no bachelor programs for D&T teacher education; all D&T teachers undergo the Postgraduate Diploma in Education for teaching at the secondary level (PGDE, Secondary) offered by the National Institute of Education (NIE), Nanyang Technological University (NIE, 2024). In NIE, D&T teachers will study Teaching and Evaluating Design Process, Material Processing, Pedagogical studies specific to D&T teaching, and management of D&T learning.

In Taiwan, TE is offered as a general education subject called Living Technology in junior high and high schools. The Living Technology subject at both junior high and high school takes on a heavy focus on design thinking (Ku & Lin, 2020). At the junior high school level, the curriculum focuses on "Creative Design"; during the high school level, the curriculum focuses on "Engineer Design". To prepare teachers to engage in design-based learning in the classroom, the teacher training program, based on the program offered by National Taiwan Normal University, offered design-related studies like basic design, engineering design, product design, model making, etc.

For D&T and TE teachers to be competent in planning and implementing design-based learning in the classrooms, it can be observed that university programs for D&T and TE teacher education in Australia, Singapore, and Taiwan provide the teachers with some forms of design knowledge within the education degree programs.

3. Research Methodology

3.1. Research questions

For this study, two research questions (RQ) are framed. RQ1) What are the key challenges faced by Japanese beginning TE teachers when planning and implementing design-based learning in technology lessons? RQ2) What are the key considerations for university academics to help Japanese beginning teachers overcome the challenges faced in RQ1?

3.2. Research methods

This study applied a qualitative inquiry strategy based on the principle of purposeful sampling to create a single significant case study. This case study will use a self-study approach as the purposeful sampling strategy. Purposeful sampling is where the cases for study are selected because they are information-rich and can provide deep insights into the phenomenon (Patton, 2015). As a self-study approach, one's own experience of a phenomenon will be examined. This self-study is based on a collaborative design-based project that the authors have worked together and implemented in the technology lessons in the academic year of 2023.

3.2.1. Significance of establishing the study as a self-study for purposeful sampling

The need for research was inspired by the development of the NGTE and the call by Moriyama et al. (2024) on the need to reform teacher education and professional development. As the scope for teacher education and professional development is extensive, the scope of this research will focus on upskilling and supporting beginning TE teachers. Beginning teachers in this study refer to teachers with 3 years or less of teaching experience.

The current case study is conceptualized to be a collaboration between a university academic and a beginning teacher. The first author is an academic in the Faculty of Design of a local Japanese

university. In addition, the first author is a trained teacher with about eight years of teaching experience teaching D&T in Singapore schools. During his time in the teaching service, the first author took on a leadership position in the school and had opportunities to work with D&T teachers to design and implement D&T in the schools. Although the first author is a trained D&T teacher in Singapore, as an academic in a Japanese university, he has conducted school visits in Japanese junior high schools and organized online sharing sessions with Japanese TE teachers to understand and learn about TE in Japan. Thus, as an academic, the first author has a pretty good understanding of TE in Japanese junior high schools. The second author is a beginning teacher with 2 years of teaching experience teaching TE in a Japanese public junior high during the time of research. The second author graduated with a bachelor's degree from the School of Education at a local university specializing in TE. In addition, the second author also obtained a master's degree in design from the Graduate School of Design at another local Japanese university. Within the TE fraternity in Japan, few TE teachers are trained in design.

The education profile of the second author provides the ingredients to establish a significant sample for a case study to understand the challenges faced by a beginning TE teacher who is design-trained when planning and implementing design-based learning in the TE classroom. Based on the development profile of the first and second authors, a self-study as a form of case study will provide valuable insights for TE researchers and educators.

3.2.2. Establishment of the collaborative design-based project for research and the roles of the researchers

The roles of the first and second authors in the collaborative design-based project were established as follows. In this collaborative design-based project, the first author provides the know-how and advice for the development and planning of the design-based project. The second author planned, taught, and facilitated the design-based project. In addition, the second author determined how the design-based project should be integrated and implemented into the school's TE curriculum.

In Fukuoka City, junior high school TE teachers formed a Fukuoka City TE association to conduct professional development activities such as study groups, educational research, lesson observations, consultation with the city board of education, etc. In 2023, the second author was tasked to work with a small group of TE teachers by the Fukuoka TE association to explore and develop new prototype lessons or projects as a form of Group Research activity (教科一斉研究授業) that can be shared with teachers in Fukuoka city. This Group Research and Study activity provided an opportunity for the first author to collaborate with the second author to plan and implement a design-based project that the second author had not done before in his TE classroom. At the same time, as part of the Group Research activity, six other supporting TE teachers from other junior high schools also came in to work with the second author during the planning stage of the project.

3.3. Research design and implementation

3.3.1. Conceptualization and implementation of the collaborative design-based project for research

The TE curriculum is usually planned before the academic year begins, when and how the project is implemented requires careful consideration. The project's duration should not disrupt the overall TE curriculum for the academic year. However, ideally, the duration should not be too short as the design-based project should allow students to experience a complete design cycle.

The design-based project was placed in the second semester of the TE curriculum for 2nd-grade students, as the 1st-grade TE was planned to teach fundamental knowledge and skills. It was also not feasible to conduct the project in the 3rd grade as the number of lessons for TE is half that of the 1st and 2nd Grades. The design-based project for this study is planned to be eight lessons as it was deemed to be more manageable and less disruptive to the existing curriculum.

Before deciding on the theme, the second author identified the key topics that students were required to learn in the second semester. Then, the first and second authors, together with the six supporting TE teachers, held discussion sessions to brainstorm how some key topics could be integrated and taught as part of the design-based project. This project would focus mainly on biological technology topics but also integrate other key learning content such as material and processing, design process, science, and mathematics.

Through this design-based project, the key learning outcomes were: 1) Students should be able to understand the process of cultivating and harvesting a plant; 2) Students should be able to evaluate and improve the method of cultivating a plant based on different points of views; and 3) Students should be able to solve complex problems through the design and make process.

As the duration of the project was only eight weeks, it was important to select a plant that may allow students to experience growing and harvesting process. The white radish sprout (かいわれ大根) was selected as the plant to grow during the project. To allow the students to design and make a prototype, the design brief was set as below (Translated from Japanese):

What kind of image would students imagine when it comes to agriculture? As technology advance, agricultural activities may take on a very different approach. Recently, high-tech farming activities can include urban farming, hydroponics, use of robotics and drones. In addition, due to uncertain developments in the future that may include pandemics and high cost. There may be users who would like to grow vegetables in their own kitchen. It may also be an educational experience during such growing process. As such, students are to design and make a farming kit that can allow users to grow certain vegetables in their kitchen areas.

The theme of the project is called Kitchen Farm (キッチン農園キット). The project plan is explained in Table 1. Students will work in groups of about 5-6 students. Three classes of 2nd-grade students went through the Kitchen Farm project. The class size for each class is about 33 students.

Table 1
Project plan for design-based project in this study

Project Stage	Key Lesson Activities	Students' Learning Outcomes	Duration
Stage 1	a. Explanation of project brief b. Problem exploration and understanding c. Research on the required environment d. Research and test grow the vegetable e. Research on user needs	1. Acquire the principles, laws, and basic skills of cultivation 2. Able to organize and summarize appropriately from the results of cultivation	3 Lesson
Stage 2	a. Defining design specifications b. Ideation c. Evaluation of ideas d. Manufacturing process e. Selection of final idea and making of model	1. Able to evaluate ideas clearly and logically with justifications 2. Able to propose an appropriate solution through trial and error	3 Lesson
Stage 3	a. Writing of user manual for proposed solution b. Presentation of proposal	1. Able to explain cultivation methods in an easy-to-understand manner 2. Able to communicate proposals based on evidence in an easy-to-understand manner	2 Lesson

3.3.2. Data Collection and Analysis

The object of study is mainly based on the qualitative data collected from the teacher's reflection (the second author) after the implementation of the project. The reflections are recorded in the Microsoft Word Document. Tables 2 and 3 present the reflection questions concerning the research questions. Based on the content of the teacher's reflections as findings, the first author analyzes the data to elucidate meanings. As a form of qualitative interpretation, the first author attaches significant meaning to the reflections, making inferences and extrapolating lessons to be learned from this finding. It should also be noted that the interpretations are based on the analyst's (the first author) own perspective and understanding to make sense of the findings collected.

Lesson plans, student journals, presentation slides, and prototypes are collected as supplementary data to further understand the key findings when analyzing the teacher's reflections. Refer to Figure 1. The lesson plans will provide a clear view and understanding of each lesson's activities. The student journals provided a record of the students' design process, as well as strengths and opportunities for improvement in teaching instructions.

Table 2

Breaking down RQ1 into sub-questions to be used as teacher reflection

Research Questions	Sub-Questions for Reflections	Purpose
RQ1	What knowledge and skills related to design-based learning do beginning TE teachers have?	To identify the knowledge and skills that beginning TE teachers have with respect to design-based learning
	What knowledge and skills do beginning TE teachers lack when planning design-based learning in Technology?	To identify the knowledge and skills that beginning TE teachers may lack with respect to planning design-based learning
	What knowledge and skills do beginning TE teachers lack when implementing design-based learning in Technology?	To identify the knowledge and skills that beginning TE teachers may lack with respect to implementing design-based learning
	What challenges do you face when planning and implementing the design-based project in this study?	To identify the possible issues faced by beginning TE teachers through this study
	What kind of support do you need when planning and implementing design-based projects in your classroom?	To identify the possible opportunities for support for beginning TE teachers through this study

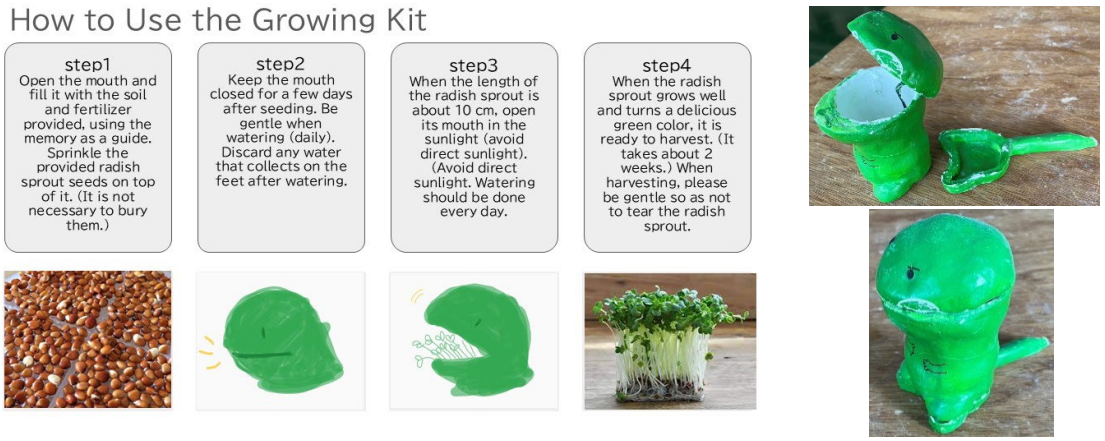
Table 3

Breaking down RQ2 into sub-questions to be used as teacher reflection

Research Questions	Sub-Questions for Reflections	Purpose
RQ2	What kind of support do you need from university research labs when planning and implementing design-based learning in Technology lessons?	To identify the possible opportunities for supporting beginning TE teachers to plan and implement design-based learning in TE classrooms
	How do you think university research labs can support you when planning and implementing design-based learning in Technology lessons?	To identify the possible strategies for supporting beginning TE teachers to plan and implement design-based learning in TE classrooms

Figure 1

A Japanese-English translated version of the user manual for the prototype named "Radish Sprout Monster" was created by students.



4. Findings and Discussions

This section presents the key findings and interpretations based on the teacher's reflections.

4.1. Teacher's perception on the current gaps of Japanese beginning TE teachers in knowledge and skills for design-based learning

The teacher organized the knowledge that beginning TE teachers should acquire for design-based learning into three major areas: 1) awareness of the concepts of design-based learning, 2) awareness of objectives, processes, methodologies, and issues involved in design-based learning, and 3) acquiring skills required to implement the design process and methodologies.

TE activities in the classrooms are often implemented as design and problem-solving activities, even though the teachers may not be very clear about the concepts of design-based learning. The teacher reflected that it can be confusing for beginning TE teachers to understand and differentiate the concepts of design and problem-solving stated in the TE national curriculum. The teacher recognized that the concept of design in TE requires students to design and make prototypes specific to the design problems they are solving. Considering the current equipment available in TE workshops, there are limitations to the ability to prepare lessons, teaching materials, and materials for students to conduct trial and error through prototyping. However, these issues may be mitigated by introducing digital fabrication tools such as 3-D printers and laser cutters.

As for design process and methodologies, the teacher felt that beginning TE teachers are constantly exploring different design activities and methodologies for design-based activities, such as presenting problem brief, development of ideas, iterative cycles of design process, etc. Through these explorations, they have acquired awareness of the available resources that provide such information. However, there is no systematic approach to provide opportunities for beginning TE teachers to understand the design process and methodology. There is also a general feeling that TE teachers misunderstand the design process as a procedural and linear process rather than an iterative process. In fact, the teacher reflected that he was not confident if he understood the design process and methodology sufficiently.

Regarding the third area, the teacher felt that current TE teachers are developing limited facilitation and prototyping skills through the current teaching and management of TE in schools. This may be the result of current design and make activities practices, where projects mostly involve students in the class making similar prototypes. The teacher considered lesson planning skills and teaching strategies may be divided into those that can be applied across the TE subject and those that are specifically necessary for design-based learning. Planning and implementing regular TE lessons that may not include design-based learning can be challenging for beginning TE teachers. Regarding design-based learning, beginning TE teachers lack the necessary skills to set design tasks, facilitate the design process, provide consultations during ideations and prototyping, time management for design-based activities, and assess students' design outcomes.

4.2. Challenges faced to plan and implement design-based learning for this study

In planning and implementing the Kitchen Farm project for this study, the teacher highlighted several issues. As a pre-requisite to implementing design-based learning, understanding the design process is necessary. In addition, facilitation skills such as how and when to conduct design conversations to direct and lead students during the design process are vital. The teacher found it challenging to guide students as the processes in the design project were new to students. In addition, teachers also found it challenging to lead and advise students who were not progressing well during the designing process. After the project, the teacher felt he lacked knowledge and skills in conducting post-project evaluation, such as what learning outcomes were achieved and how students' outputs could be assessed.

Preparation and maintenance of the workshop environment was another challenge that the teacher faced. In previous TE projects, students were provided with the same materials as they often design and make artefacts within the scope of the provided materials. When students are allowed to design and make different types of solutions in design projects, the type of materials that

students need can only be determined when they develop the design ideas in more detail. Thus, the preparation of materials is a challenge for beginning TE teachers. Not to add that the administrative processes to secure the budget and the materials required can also be challenging. In addition, a wide range of tools and machines are also required if students are to design and make a wide range of design solutions.

4.3. Consultations and support

Regarding support from university academics, the teacher reflected that regular consultations to discuss and acquire knowledge and effective practices for design-based learning are necessary. In fact, many of the challenges faced by beginning TE teachers can be tackled through such consultations. Academics can also collect best practices and share them with teachers promptly. In addition, other forms of support that the teacher hopes to receive include practical examples, teaching and learning resources, and regular checks by academics to determine if the beginning TE teachers are implementing their TE lessons in the correct direction as stated and intended in the national curriculum. To mitigate the lack of various physical resources, a "material resource bank" can also be provided by universities where schools can lend out and return later. Another way to tackle the lack of resources is to create a collaborative cluster of public junior high schools where resources, technical support, and personnel support can be provided.

4.4. Discussions and consolidations

As a consolidation, this section highlights several key considerations when planning and developing professional development support for Japanese beginning TE teachers to be competent in designing and implementing design-based learning. Firstly, teachers need to understand that the design process is iterative rather than linear. In addition, teachers need to differentiate between well-defined and ill-defined problems. In design-based learning, design problems are complex problems, also known as ill-defined problems, where not all information about the problem is known. The nature of complex problems is such that there can be many solutions to solve the problem. Thus, each student can solve a different design problem from other students. Teachers need to facilitate students to engage in the design process at a different pace. Compared to implementing projects where all students are doing the same product, facilitating design-based learning requires different teaching and learning strategies and assessment methods. As such, beginning TE teachers must be equipped with the capacity and competency to provide meaningful formative feedback to each student and facilitate the students to complete their design projects within the project timeline.

The current learning environment and personnel support will require reviews. The current tools and machines in the TE workshops require a review if TE teachers are to conduct design-based learning. TE workshops will need to be equipped with tools and machines that can allow students to create a wide range of design solutions. In overseas countries, such as Taiwan, Australia, and New Zealand, it is not uncommon to find a variety of equipment, such as 3-D printers and laser cutters, in workshops to allow students to create a wide range of prototypes. In addition, extra personnel to support TE teachers should be seriously considered. In the school where the second author is teaching, only one TE teacher is employed to manage and teach TE. In Singapore public secondary schools, each school may employ instructors to assist teachers in material preparations, machine maintenance, procurement, and so on.

The collaboration between university academics and beginning TE teachers is important. Through research and development, academics support TE teachers by creating effective teaching and learning resources. In addition, academics can conduct comparative studies to surface best practices in local and overseas junior high schools. These findings can be valuable examples and resources for TE teachers on the ground. Besides, beginning TE teachers need help reviewing and evaluating their teaching practices to determine if they are on the right track. To address teachers' needs, academics can form a collaborative partnership with TE teachers to co-design resources

and strategies and even explore possibilities of co-teaching to provide opportunities for beginning TE teachers to learn through role modeling experience academics or even progressive TE teachers.

5. Conclusion

This research aims to clarify the key factors required to create support structures through junior high school and university collaboration, empowering beginning TE teachers to implement design-based learning in their school technology curricula. While the findings are primarily qualitative in a self-study approach, the key factors can be grouped into 1) developing an understanding of design-based learning, 2) developing TE teachers with the necessary teaching and learning strategies, 3) preparations for the learning environment, and 4) creating opportunities for consultation and support through universities and cluster schools.

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