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Development and Verification Survey of Human Resource Development Program in Engineering Utilizing E-Learning System and Project Based Learning in Engineering with The Cooperation of Japan and Thailand for the New Normal after COVID-19

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Abstract: *Thai economy has been developing remarkably, especially in the manufacturing industry, and continuous and progressive economic growth is expected in the future. In addition, for further development in the future, it is essential to train high-level engineers for key industries such as automotive, environment, and information technology, and key technologies such as IoT and AI. This time, CeFox Co., Ltd., which develops e-learning systems and assists in content development in collaboration with Japanese industries and universities, and King Mongkut's University of Technology Thonburi, which trains highly skilled engineers in Thailand, collaborated to develop an Engineers' Education Program in cooperation with Industry and Universities", through a blend of the e-learning system FoxE3, and face-to-face classes using zoom, etc., based on the Japanese basic philosophy "monozukuri". We also conducted a demonstration of this program for university students, and succeeded in developing the skills required in all participants to become an engineer in a phased and effective manner. In this paper, based on the features of this program and the results of the demonstration, we report that this program is an effective for training high-quality engineers even in the midst of the COVID-19.*

Keywords: e-Learning System, engineers' education program, monozukuri, cooperation with Industry and universities, new normal after COVID-19

1. Introduction

Thai economy has been developing remarkably, especially in the manufacturing industry, and continuous and progressive economic growth is expected in the future. In addition, for further development in the future, it is essential to train high-level engineers for key industries such as automotive, environment, and information technology, and key technologies such as IoT and AI. In addition, these industrial structures and technologies are experiencing extreme changes, and engineers are required to have the skills to always be aware of market trends and to respond flexibly to these changes. On the other hand, in order to train highly skilled engineers in Japan,

CeFox Co., Ltd., (Hereinafter referred to as CeFox), which develops content in collaboration with the e-learning system "FoxE3" and Japanese industries and universities, and King Mongkut's University of Technology Thonburi (Hereinafter referred to as KMUTT), which develops highly skilled engineers in Thailand, have collaborated and developed an "Engineers' Education Program in Cooperation with Industry and Universities" through a blend of e-learning systems and face-to-face classes using zoom, etc., which enables students to acquire the experience and know-how pertaining to Japan, which has produced many top-share products and technologies in the world, through design and manufacturing based on the Japanese basic philosophy "monozukuri". This time, we conducted a demonstration of this program for students at KMUTT in the midst of the COVID-19, and succeeded in developing the skills required in all participants to become an engineer in a phased and effective manner. As a result, this program proved to be effective for engineers' training even in the midst of the COVID-19.

2. Development of Human Resource Development Program in engineering

(1) The features of the Development of Human Resource Development Program in engineering

The Development of Human Resource Development Program in engineering has three features. The first feature is this program offers four courses to train engineers in a step-by-step manner. The second feature of this program is that it is a blended educational program that combines an e-learning system with in-person classes. In these courses, Japanese engineers, researchers, and managers will come in as instructors, and conduct in-person classes. The third feature is the evaluation method. This program allows students to visualize the leaning state of e-learning systems as they take classes, as well as the state of their skill acquisition through presentations. Such features enable us to logically identify students who need follow-up and support, and to easily improve the skills of many more students.

(2) Four courses to train engineers

This program offers four courses to train engineers in a phased manner.
The first course is the Technology Development Course, in which students learn about the features and target markets of technologies and products used worldwide in fields such as automobiles, the environment, medicine, and information technology, as well as the social background that gave birth to each technology and future challenges. In this way, students will be able to improve their ability to logically design technologies that are necessary to discover and solve social issues. The next course is the Technology Management Course, where students will learn the procedures for research and development of new technologies, as well as the procedures and concepts necessary to start a business.

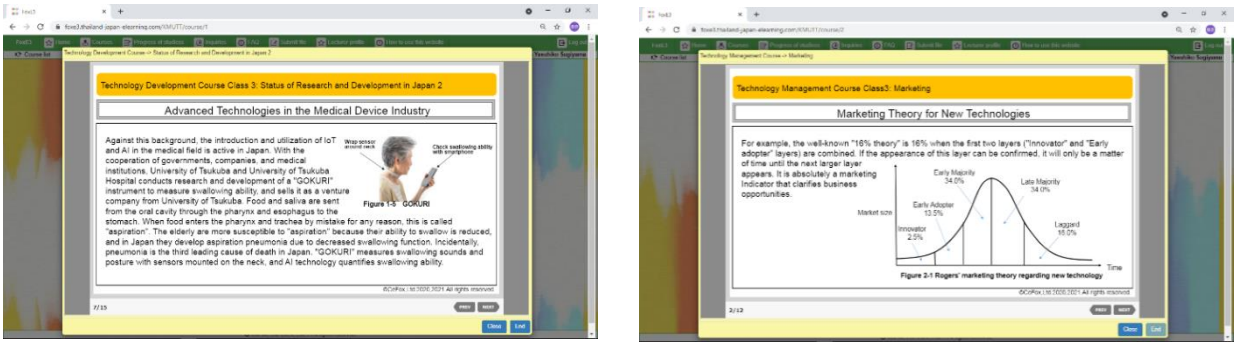


Figure 1: Text of Technology Development Course and Technology Management Course

In particular, in this course, students can learn not only the examples of success in Japan, but also examples of failures and re-challenges based on the experiences of failures, and can acquire know-how for leading the new businesses to a greater success. Figure 1 shows the contents of the Technology Development Course and the Technology Management Course.

The third course is the Career Development Course, where students learn about the concept of "monozukuri," manners necessary as a member of society, human resource development systems within the company, and the importance of 'team communication' and 'HOU-REN-SOU (report-contact-discussion) ' when working within a corporate organization. In particular, it is a must-see for Japanese companies operating in Asia to see what kind of skills they need from local engineers in order to expand their business as a part of their future management development.

Up to this point, students study on their own through the e-learning system, but the final course is the Project Based Learning Course that is conducted entirely face-to-face, where students are divided into small groups, analyse actual social issues and factors, and plan technologies, targets, and development methods to solve them. The students then develop and verify the proposed technologies, and based on the results of the verification, the students self-evaluate the differences from the original goals, the reasons for the differences, and future improvements. In other words, this course is the compilation of the other three courses, and allows students to experience the process of research and development in line with the real world. Figure 2 shows the contents of the Career Development Course and the Project Based Learning Course.

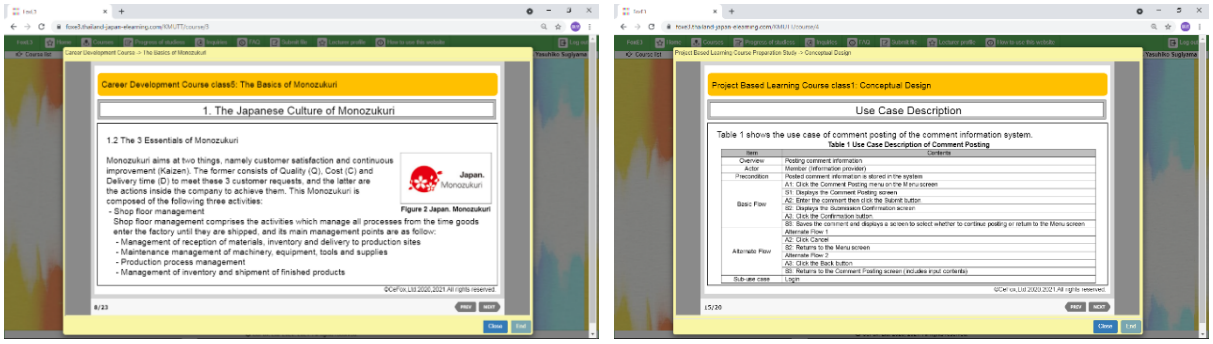


Figure 2: Text of Career Development Course and Project Based Learning Course

(3) Blended educational program combining e-learning system and face-to-face classes

In each course, face-to-face lectures are given by Japanese engineers, researchers and managers. Specifically, in the Technology Development Course and the Technology Management Course, students formulate the social issues and factors that may occur in their home countries in the future, the technologies and development methods to solve them, and the plans for commercialization, and get advice for this from Japanese lecturers. By repeating this process, students will be able to improve the problem-solving and logical thinking skills they need to become engineers.

In the Career Development Course, students also present their own career plans, and depict how they would like to see themselves in five to ten years' time on their way to achieve their future dreams. They also analyse their own strengths and weaknesses and plan how to develop themselves to achieve their dreams. In response, Japanese lecturers will provide advice and support to help students realize their dreams.

In the Project Based Learning Course, each group will make a total of three presentations: Conceptual Design, System Design, and Evaluation. For each presentation, the Japanese lecturer will give pointers and advice to the students, who will then move on to the next presentation. In other words, students can experience development similar to that of the real world, and this enables them to acquire the skills required to become an engineer in a logical and phased manner. Figure 3 shows the overall picture of the blended education program.

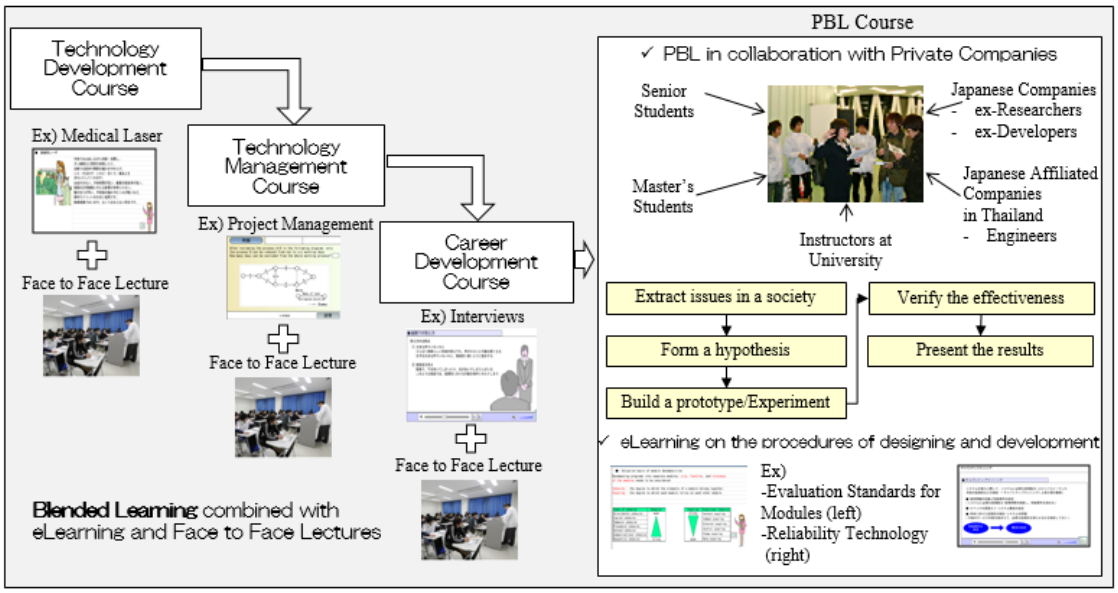
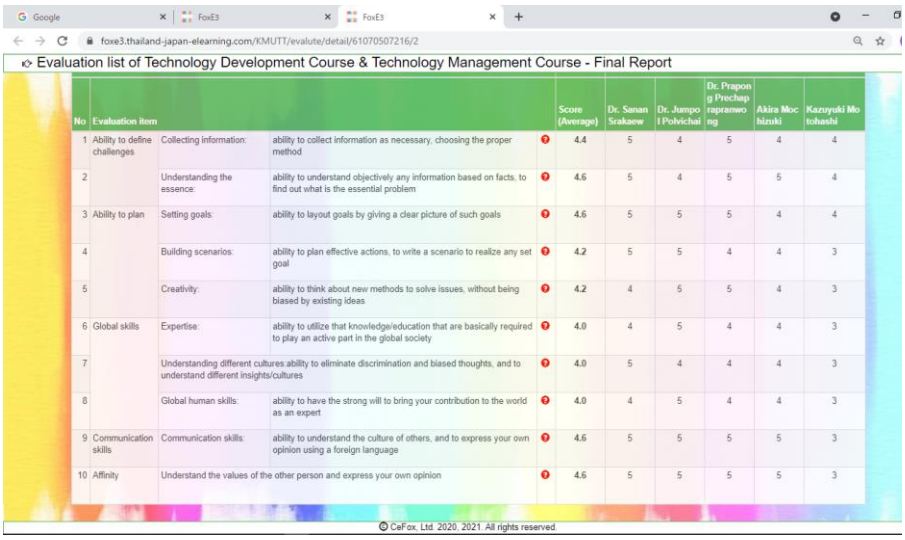


Figure 3: Overview of blended educational program

(4) Visualization and evaluation of the acquisition status of skills required to become an engineer

In this program, through various presentations by the students, we visualize the acquisition status of the skills of each student that are required to become an engineer. Specifically, we systematized about 40 skills necessary for engineers, including skills related to problem solving and planning necessary for research and development, skills related to design and development, and social skills such as communication and understanding others when working in a team. Japanese lecturers and Thai university teachers evaluate each skill at the time of presentation and students can understand their strengths and weaknesses on the e-learning system. In addition, since it is possible to monitor the learning progress of individual students on the e-learning system, it is possible to logically derive which students need follow-up and support and how to support them, thus easily improving the skills of more students. Figure 4 shows a part of the skill acquisition status displayed by the e-learning system.


Evaluation list of Technology Development Course & Technology Management Course - Final Report

No	Evaluation item			Score (Average)	Dr. Sanan Srakaew	Dr. Jumpot Polvichai	Dr. Prapong Prechaprapranwong	Akira Mochizuki	Kazuyuki Mochizuki
1	Ability to define challenges	Collecting information:	ability to collect information as necessary, choosing the proper method	4.4	5	4	5	4	4
2		Understanding the essence:	ability to understand objectively any information based on facts, to find out what is the essential problem	4.6	5	4	5	5	4
3	Ability to plan	Setting goals:	ability to layout goals by giving a clear picture of such goals	4.6	5	5	5	4	4
4		Building scenarios:	ability to plan effective actions, to write a scenario to realize any set goal	4.2	5	5	4	4	3
5		Creativity:	ability to think about new methods to solve issues, without being biased by existing ideas	4.2	4	5	5	4	3
6	Global skills	Expertise:	ability to utilize that knowledge/education that are basically required to play an active part in the global society	4.0	4	5	4	4	3
7		Understanding different cultures	ability to eliminate discrimination and biased thoughts, and to understand different insights/cultures	4.0	5	4	4	4	3
8		Global human skills:	ability to have the strong will to bring your contribution to the world as an expert	4.0	4	5	4	4	3
9	Communication skills	Communication skills:	ability to understand the culture of others, and to express your own opinion using a foreign language	4.6	5	5	5	5	3
10	Affinity	Understand the values of the other person and express your own opinion		4.6	5	5	5	5	3

Figure 4: Acquisition status of skills displayed in the e-learning system

3. Verification Survey of Human Resource Development Program in engineering

(1) Demonstration at KMUTT

KMUTT is a national technical university located in the Kingdom of Thailand. KMUTT is located in the centre of Bangkok and a science and technology university that fosters educational innovation, research, creativity and entrepreneurship to build a strong and sustainable society. KMUTT has 52 undergraduate courses, 68 master's courses and 33 doctoral courses. There are 11940 undergraduate students. The graduate school has 1966 students in the master's program and 457 students in the doctoral program. The number of faculty members will be 850. Figure 5 shows the exterior of the KMUTT school building and classroom.

Figure 5: Appearance of KMUTT and classroom

This program was demonstrated for 36 students at KMUTT from January to June 2021. Each course was conducted as a credit-bearing course. This is the first time in Thailand that a course, consisting of an e-learning system for almost all lessons, is a credit-bearing course. The demonstration is right in the midst of the COVID-19. The students' place of study was at home, and presentations by students were conducted online using zoom and Teams. In order to acquire the technical and social skills necessary for engineers, precise and direct guidance by a mentor is important, but achieving this online is the success point. Therefore, students and university teachers, students and Japanese lecturers, university teachers and Japanese lecturers were closely connected. In addition, discussions between the Japanese lecturers of each course and the students, Q&A between the students and the lecturers on the e-learning system, and

individual guidance using zoom, etc. were incorporated. Figure 6 shows the Q&A on the eLearning system from students to Japanese lecturers. Figure 7 shows the Discussion between students and Japanese lecture online.

Figure 6: Q&A on the eLearning system from students to Japanese lecturers.

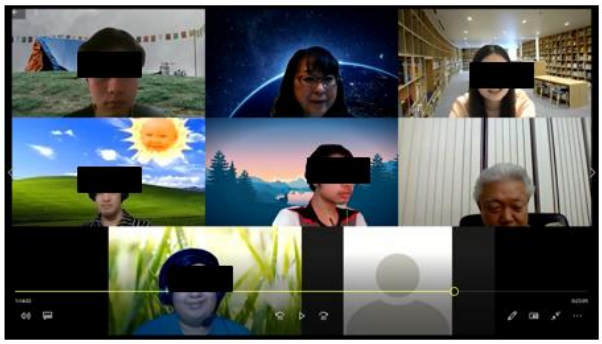


Figure 7: Discussion between students and Japanese lecture

As a result, we received many questions from the students, and as many as 70% of the students requested for online individual tutoring. Figure 8 shows the flow of the demonstration of the Technology Development Course and the Technology Management Course.

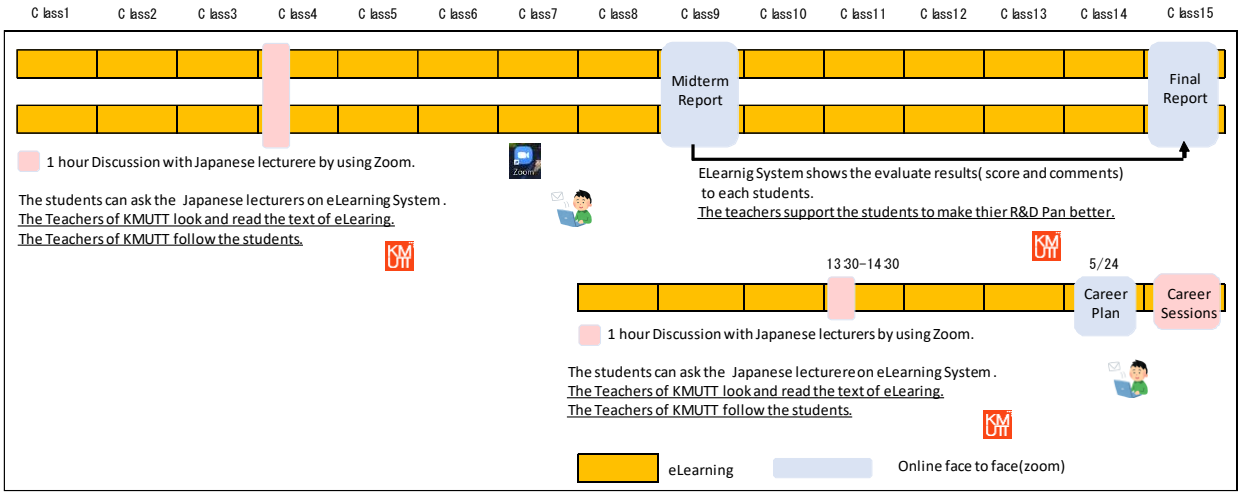


Figure 8: Flow of the demonstration of Technology Development Course and Technology

(2) Result of the demonstration

Using the Technology Development Course and the Technology Management Course as an example, Fig. 5 shows the progress of the acquisition status of the skills required to become an engineer for the 36 students who participated in the mid-term and final presentations of the course.

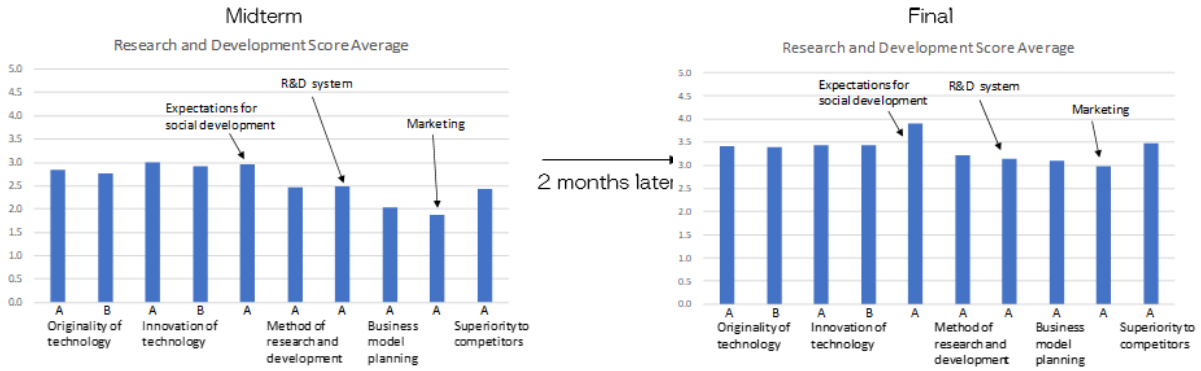


Figure 9: The status of skills acquired by students in midterm and final presentations

As shown in Figure 9, the skills of all 36 students improved. The average evaluation score of R&D skills in the midterm presentation was 28.8 points (Out of 50 points, maximum score: 35.0 points, minimum score: 24.2 points), while the average score in the final presentation just two months later improved to 36.6 points (maximum score: 41.0 points, minimum score: 32.2 points). This was due to the following factors: In the two months between the midterm presentation and the final presentation, we were able to follow up via e-mail and LINE with the students who were making slow progress on the e-learning system, and from the results of the mid-term presentation, we were able to effectively utilize the visualized skill acquisition status focusing on the skills in which individual students have low scores by, for example, providing individual guidance via Zoom to students with weak skills in marketing in R&D.

Figure 6 shows the distribution of students, based on the evaluation results after the completion of all courses, when the target of each course is set to 75% of the evaluation score.

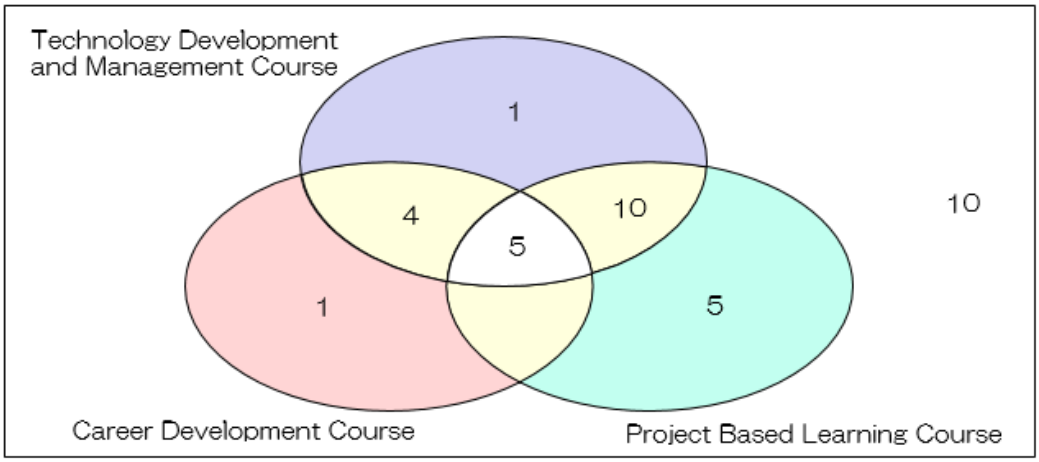


Figure 10: Distribution of students when the target of each course is set to 75% of the evaluation score.

The five students who achieved the target values of all courses are in the centre of Figure 10. Furthermore, from Figure 6, the strengths and weaknesses of the students can be visualized, and the future educational policy required for each student can be clarified. For example, for

the four students who did not achieve the target value only in the Project Based Learning Course, it is necessary to cultivate their practical and collaborative skills, and it is easy to formulate a guidance policy tailored to individual student, such as encouraging them to participate in research and development projects executed in the laboratory in collaboration with companies or to participate in exercise courses.

3. Discussion and Conclusion

It is no exaggeration to say that Asia is the key to success of the global economic development in the future. The highly skilled engineers who will play a key role in this are the human resources who can accurately grasp social issues and solutions, understand the procedures for success in business, and implement them as a team. The results of the demonstration show that "Engineers' Education Program in cooperation with Industry and Universities" is an effective means of fostering highly skilled engineers even in the midst of the COVID-19. In addition, this program is suitable not only for knowledge-based training but also skill improvement-based training, and the training method of this program can be applied to various fields such as medical care and environment. In addition, this program also serves as a powerful educational tool for engineers working in companies. After the COVID-19 crisis, the transition from group-based education to online education is obvious, and for companies, it provides an excellent return on investment by giving more employees the opportunity to step up their skills. Finally, I would like to thank everyone at the Office of the National Higher Education in Thailand for their cooperation in the development and demonstration of this program in the midst of the COVID-19 pandemic.

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