Practical Study on Multicultural and Multi-disciplinary Team-based, Project-based Learning Dealt with Real-World Problems in Engineering Education

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ABSTRACT

Multi-cultural and multi-disciplinary problem-based or project-based learning (hereafter, PBL) is well-known as an effective approach for enhancing global competencies for engineers. On the other hand, higher education involves enhancing students' readiness for industrial careers after graduation. Thus, a challenge in engineering education is to respond to engineering problem-solving in the real-world for bridging a students' gap to transfer from university to industry.

Giving the above, this study aims to prove the effectiveness of—and challenges in—multi-cultural and multi-disciplinary team-based PBL dealt with real-world problems in engineering education through the case study of the Global Dormitory (G-DORM) project. The G-DORM project, a bilateral student exchange project organized by Japan's Niigata University in collaboration with four universities from the lower Mekong countries of Cambodia, Laos, Thailand, and Vietnam, developed a pedagogical approach that included 1) internships in the industry, 2) short-term industrial experiential learning, and 3) lecture courses. In particular, a PBL dealt with real-world engineering problem-solving has been predicted to enhance global engineers' competencies; however, less discussion has been devoted to learning practical effectiveness.

This study's analyzed data were extracted from the questionnaire responses of students. In the case of the internships, the data were also extracted from the questionnaire responses of selected hosting companies. The study results emphasized as follows. Firstly, G-DORM approach-based internships could positively affect students' competence with regard to global engineering, especially through the designing of stepping-up programs aimed at developing competence. Furthermore, the study results suggested the optimization of internship periods, pre-studies, intervention by moderators during internships, and improvements in post-studies as challenges for future works. Secondly, the short-term industrial experiential learning in G-DORM increased students'

satisfaction and interests in the regional industry as well as developed the motivation and the actual action of students in a step-up tendency. Thirdly, the result of the lecture course where students proposed science and technology (Sci-tech) challenges for Sustainable Development Goals (SDGs) by team-based learning implicates that most of the students understood and emphasized the importance of the relationship between engineering and society. Furthermore, the students rated this active learning as useful as a pre-study for the internship in the industry.

In conclusion, the study indicates that multi-cultural and multi-disciplinary project-based, internship-based learning effects to enhance students' global engineering competence. In addition, the internship in combination with the pedagogical methodology of the short-term industrial experiential learning and the lecture course helps to supplement the disadvantage of the internship.

CONTENTS

LIST OF ACRONYMS AND ABBREVIATIONS

AI	Artificial Intelligence
AY	Academic Year
COVID-19	Coronavirus Disease 2019
CU	Chulalongkorn University
FCWP	Fundamental Competencies for Working Persons
G-DORM	Global Dormitory
GW	Group Work
HUST	Hanoi University of Science and Technology
ICT	Information and Communication Technology
IoT	Internet of Things
IT	Information Technology
JASSO	Japan Student Services Organization
METI	Ministry of Economy, Trade and Industry
MEXT	Ministry of Education, Culture, Sports, Science and Technology
MSC	Most Significant Change
NGO	Non-government Organization
NU	Niigata University
PBL	Project-based learning, or Problem-based learning.
Q&A	Question and Answer
RUPP	Royal University of Phnom Penh
Sci-tech	Science and Technology
SDGs	Sustainable Development Goals
SNS	Social Networking Service
STI	Science, Technology and Innovation
TOEIC	Test of English for International Communication

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CHAPTER 1
INTRODUCTION

1.1 Background and Objectives

In recent times, engineering education has been facing a major issue with regard to the fostering of students as global competent engineers against the context of globalization. Factors of global competence include knowledge and skills as well as attitude and identity [1]. Such global competencies for engineers are triggered by working effectively with people who define problems differently compared to them [2]. Therefore, multi-cultural and multi-disciplinary problem-based or project-based learning (hereafter, PBL) is well-known as an effective approach for enhancing global competencies for engineers. For instance, multi-cultural PBL can aid in the integration of ideas from different cultural backgrounds [3]. Furthermore, it helps students acquire the specialized communication culture-related skills necessary for living and working in diverse cultures and societies while overcoming communication barriers [4]. In addition, a multi-cultural PBL course could help to strengthen basic engineering skills and learning motivation [5]. One way to enhance engineers' global competencies through multi-cultural PBL is to train them to apply technical knowledge to real-world problems [6–8]. Both language skills and soft skills can be improved through multi-cultural PBL featuring real-world problems [9,10].

On the other hand, higher education involves enhancing students' readiness for industrial careers after graduation. Multi-cultural team-based learning has been suggested as an effective means for making improvements in career development-related individual abilities as well as cognitive and problem-solving skills [11]. According to Wang et al. [7], the main approaches for bridging the gap between the university and industry spheres are summarized as follows: 1) include more practical-oriented training in the curriculum; 2) adopt PBL and like; and 3) strengthen the university-industry partnership. Internships can also enhance soft skills such as social or interpersonal skills [12].

Thus, a PBL dealt with real-world engineering problem-solving has been

predicted to enhance global engineers' competencies; however, less discussion has been devoted to learning practical effectiveness. Therefore, this study aims to prove the effectiveness of—and challenges in—multi-cultural and multi-disciplinary team-based PBL dealt with real-world problems in engineering education through the case study of the Global Dormitory (G-DORM) project.

1.2 The G-DORM Project: A Case This Study Dealt with

1.2.1 Overview of the G-DORM Project

The G-DORM project is a bilateral student exchange project in engineering education, organized by Japan's Niigata University (NU) in collaboration with four universities from the lower Mekong countries of Cambodia, Laos, Thailand, and Vietnam: Royal University of Phnom Penh (RUPP) (Cambodia), National University of Laos (NUOL) (Laos), Chulalongkorn University (CU) (Thailand), and Hanoi University of Science and Technology (HUST) (Vietnam). As an educational concept, the G-DORM project was designed based on a “Dormitory-type Education” model; this included co-creative group work (GW) for engineering-related activities as part of PBL and involved the formation of small, multi-year, cross-departmental teams, which functioned like "dormitory" residences for students [13]. This concept is similar to that of the Learning Factory model, which focuses on experiential team-based learning that involves students, faculty members, and industry participants [7,14,15]. “G-DORM” is a truncation of “Global Dormitory.” The G-DORM project was designed by developmentally adding two major factors—multi-cultural perspective and learning in industry—to the concept of dormitory-type education. In other words, in a multi-academic year, students compose multi-cultural and multi-disciplinary groups and then tackle PBL; the main goal of PBL is for students to propose solutions for real-world problems.

The G-DORM project was launched in 2016. This project got supported by regional companies located in Niigata, which possess international development capabilities and which have extended—or are extending—businesses in the lower Mekong countries. Lower Mekong countries have become well-known for their high

economic growth potential; however, these countries face challenges in developing technologies for supporting industries; this is an area where Japanese industries, especially the regional industries in Niigata, show considerable skill. In Japan, advanced supporting technologies, such as precision processing and metal processing, which are essential for manufacturing, have become concentrated in the Niigata local area. In particular, an industrial metal processing cluster was developed in Tsubame City, Niigata, through the promotion of industrial transformation integration technologies in different fields and through the restructuring of overseas or domestic production systems through technological learning [16]. However, when we consider multidisciplinary perspectives, it is clear that regional industries, such as those in Niigata, face a problem with regard to developing global engineers. To contribute toward solving this matter with the help of engineering education, the G-DORM project set a goal of fostering global science and technology (Sci-tech) leaders who will be capable of solving regional revitalization issues from an integrative standpoint.

1.2.2 Pedagogical Approaches in the G-DORM Project

The G-DORM project developed a pedagogical approach that included 1) internships in the industry, 2) short-term industrial experiential learning, and 3) lecture courses on campus (**Fig. 1**).

As mentioned, the G-DORM project is a bilateral student exchange project. The period of the bilateral student exchange was established as three types: long-term (six months with a cumulative 2-month internship), medium-term (two months with a cumulative 1-month internship), and short-term (10 days with a 4-day industrial experiential learning). The internships in the medium-term and long-term programs and industrial experiential learning in the short-term program are designed as cross-cultural or multi-cultural and multi-disciplinary PBL modules that dealt with an existing problem in the industry. Besides, the G-DORM project established lecture courses that provide a team-based PBL opportunity to deal with real-world engineering problem-solving, where the students compose multicultural and

multi-disciplinary teams in order to enhance their global engineers' competencies. The lecture courses were conducted on the class subject “Topics in Global Science and Technology” at NU. The study in this thesis deals with the three cases shown in **Fig. 1**.

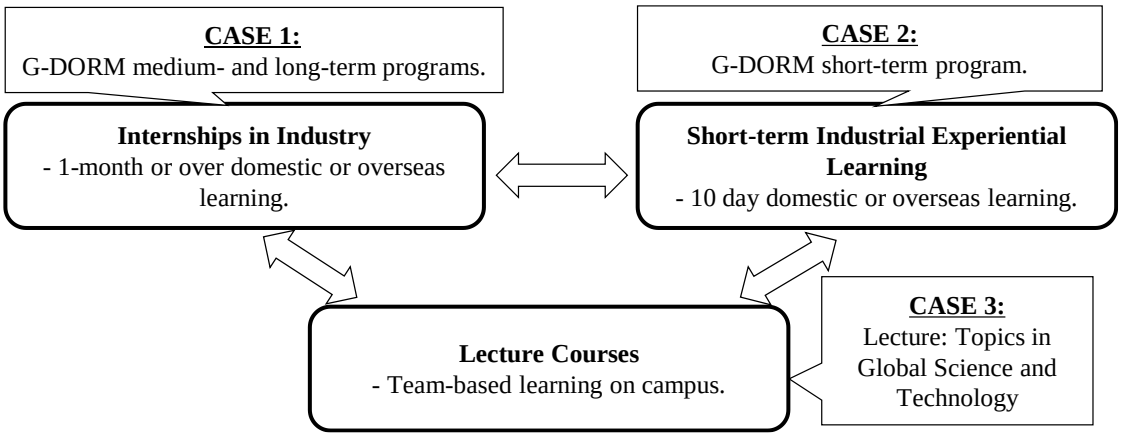


Fig. 1. Pedagogical approaches in the G-DORM project.

1.3 Research Questions

The main objectives of this study can be illustrated as proving the effectiveness of—and challenges in— the G-DORM pedagogical approaches. For the sake, the research questions are established as below;

- How much can the G-DORM pedagogical approaches enhance students’ competencies for global engineers: such as generic skills, global competencies, interests in the industry, knowledge on—and skills of applying technology to— societal problems?
- How can the G-DORM pedagogical approaches enhance students’ motivation for further learning towards global engineering careers?
- What is recommended to create the synergy of each G-DORM pedagogical approach?

To discuss seeking the answer to the research questions, this study analyzes the data extracted from the questionnaire response of students and host companies.

1.4 Structure of Thesis

This thesis is organized as follows (**Fig. 2**). Chapter 2, Chapter 3, and Chapter 4 state the results of the case studies of each G-DORM pedagogical approach as the internship in industry, short-term industrial experiential learning, and lecture courses respectively. Chapter 2 deals with the case of the G-DORM medium- and long-term programs in the Japanese academic year (AY) of 2018-2019. Chapter 3 deals with the case of the G-DORM short-term program in AY2019. Chapter 4 deals with the case of the lecture "Topics in Global Science and Technology" in AY2018. Based on these case studies, Chapter 5 concludes the thesis with an executive summary and provides some implications and limitations for future research directions.

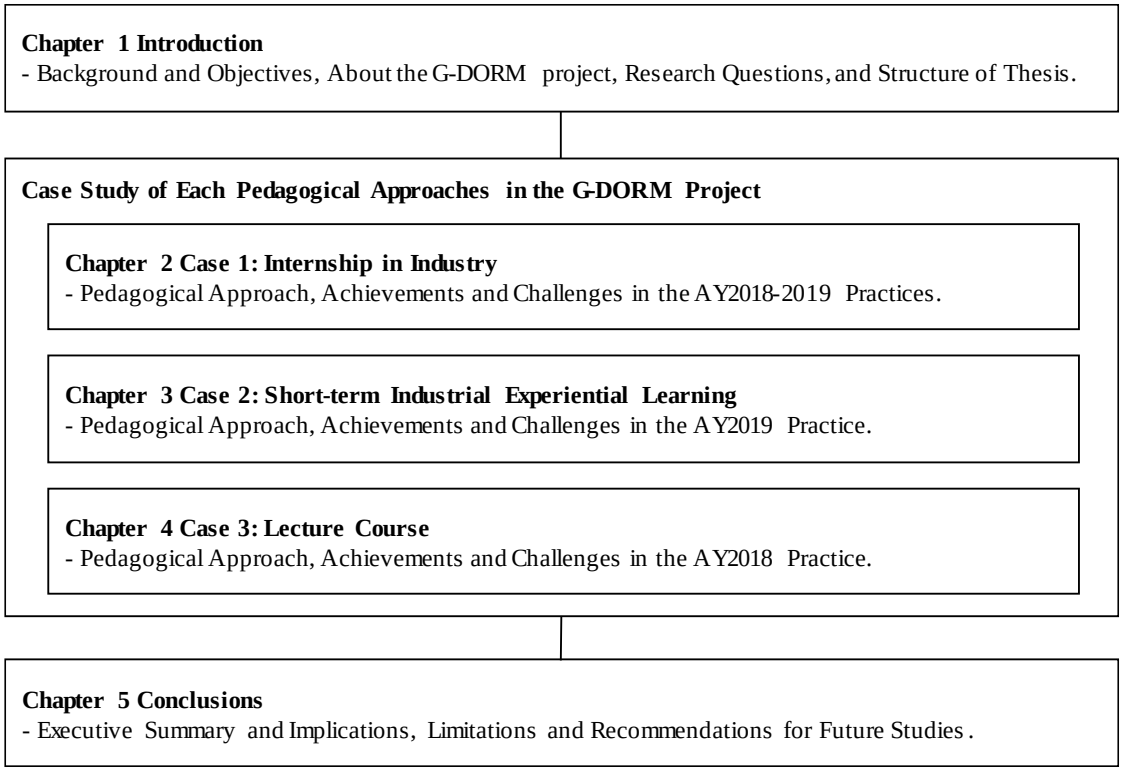


Fig. 2. Structure of this thesis.

CHAPTER 2
CASE 1: INTERNSHIP IN INDUSTRY

2.1 Introduction

Multi-cultural and multi-disciplinary PBL is well-known as an effective approach for enhancing global competencies for engineers. On the other hand, higher education involves enhancing students' readiness for industrial careers after graduation. Thus, a challenge in engineering education is to respond to engineering problem-solving in the real-world for bridging a students' gap to transfer from university to industry. Corresponding to the challenge, the G-DORM project, a bilateral student exchange project organized by Japan's Niigata University in collaboration with four universities from the lower Mekong countries of Cambodia, Laos, Thailand, and Vietnam, developed a pedagogical approach of the multi-cultural and multi-disciplinary PBL internships.

To the author’s best knowledge, few published studies, which have examined multi-cultural and multi-disciplinary PBL internships, have dealt with this real industrial problem in engineering education. One of the few reports on this subject, Wang et al. [8], conducted an integrated industry-based internship and produced a bachelor thesis on a real-world problem from 2008 to 2011. Their study concluded that industry-based internships helped to enhance students' learning motivation and understanding of the importance of multi-disciplinary perspectives because more than 90% of them tackled industry-based theses after the internship; furthermore, half of these thesis involved cross-disciplinary subjects including industry-based topics. While their results were quite interesting, however, little discussion has been devoted to the effectiveness of industry-based internships combined with multi-cultural and multi-disciplinary PBL in enhancing global competence and students' interests in the industry. These issues are critical for developing students' readiness to work in the global industry after graduation.

The objectives of this chapter are to present some knowledge that we gained by implementing a new approach for multi-cultural and multi-disciplinary PBL in

industries through the practices of the G-DORM project in AY2018 and AY2019. This chapter provides the advantages and challenges with regard to how much the G-DORM approach could enable students to enhance the following competencies: 1) generic skills for working in the industry, 2) global competencies for engineers, 3) capacity for resolving regional revitalization issues using an integrated standpoint, and 4) interests in the industry. This study's findings will help to determine how we can improve the G-DORM approach.

This chapter is organized as follows. Section 2 introduces the G-DORM pedagogical approach. Section 3 outlines our method for analyzing the effectiveness of the G-DORM practice in AY2018-AY2019, and Section 4 states the analysis results. Section 5 discusses the effectiveness and challenges of the G-DORM approach while using the abovementioned research as focal points. Section 6 concludes the chapter with a summary of the results and some future research directions.

2.2 The Pedagogical Approach

2.2.1 The Internship Period

The study in this chapter dealt with the medium-term (two months with a cumulative 1-month internship) and long-term (six months with a cumulative 2-month internship) of the G-DORM established bilateral exchange programs. The internship period at one company was tentatively set as two weeks to four weeks due to that particular company's limited capacity for accepting students. Therefore, some students engaged in the internship practice twice or more to meet the abovementioned requirements for the cumulative period of medium- or long-term programs.

2.2.2 Linguistic and Cultural Conditions in Internships

The G-DORM project internships are categorized into two types based on different locations: The internships in the lower Mekong countries and the internships in Niigata, Japan (**Fig. 3**). In the lower Mekong countries, the visiting

students were NU students only. In each lower Mekong country, NU students and local students formed a small, cross-cultural, and multi-disciplinary group and completed their internship with a Japanese-owned company. Regarding the Niigata internships, the visiting students, who were students from the four lower Mekong countries, and the NU students formed a small multi-cultural and multi-disciplinary group taking into account the balance of the academic year, specialty, nationality, and gender.

Throughout the G-DORM project, students were required to adapt to linguistic and cultural conditions (**Table 1**). Even in the Niigata internships, it was necessary for the host students to translate the internship's contents into English from Japanese and teach workplace ethics to visiting students while simultaneously considering their cultural differences. Downey et al. [2] proposed a global competencies-oriented engineering education course without international travel. Their proposed course was designed to help learners gain the following outcomes: 1) significant knowledge of national patterns in engineering, 2) an ability to find ways to identify the importance of national differences in engineering work, and 3) a predisposition toward involving engineers from other countries as co-workers. The G-DORM approach also considered the abovementioned three points in co-activities in the industry by forming cross-cultural or multicultural groups.

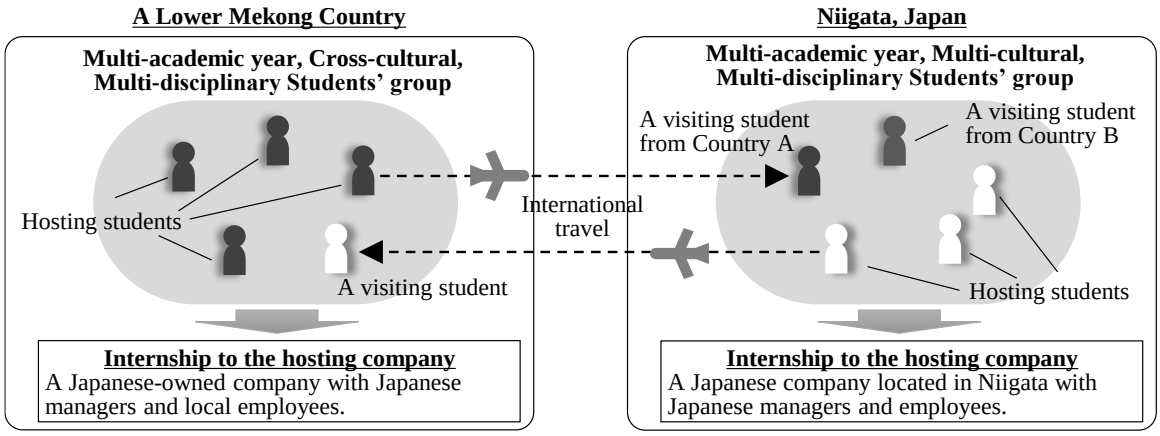


Fig. 3. Bilateral student exchanges and internships in the G-DORM project.

Table 1. Linguistic and cultural conditions in the internships.

	Internships in lower Mekong countries		Internships in Niigata, Japan	
Items	Visiting students	Hosting students	Visiting students	Hosting students
Linguistic conditions in communication				
Among students' group members	English (non-native)		English (non-native)	
With managing staff of hosting companies	Native	Non-native	Non-native	Native
With local staff of hosting companies	Non-native	Native	Non-native	Native
Cultural conditions in activities				
In students' groups	Bilateral cultural		Multi-cultural	
In working environments at the hosting companies	Native	Cross-cultural	Cross-cultural	Native
In living environments	Cross-cultural	Native	Cross-cultural	Native

2.2.3 The Learning Purpose

With regard to the internships, which are designed to foster globally competent engineers, the G-DORM approach aims to enhance the following four categorized abilities.

Generic skills: One important purpose of internships is enhancing learners' generic skills so that they will be able to work in the industry after graduation. In this regard, the G-DORM approach adopts the "Fundamental Competencies for Working Persons (FCWP)." The FCWP, which was established by the Ministry of Economy, Trade, and Industry (METI) of Japan in 2006, included three competencies and 12 competence elements. The three competencies are as follows: ability to step forward, the ability to think through, and ability to work in a team [17]. The FCWP skills are considered as generic skills [18].

Global competencies for engineers: Several studies have examined what competencies are necessary for global engineers. The five most important attributes for excellent performance in global competence are reported to be as follows: 1) appreciation for other cultures, 2) proficiency in working as part of—or in directing—a multicultural team, 3) ability to communicate across cultures, 4) opportunity to practice engineering in a global context through international

internships, and 5) ability to effectively deal with ethical issues [19]. Specifically, good communication, appreciation toward cultural differences and teamwork have been emphasized as highly rated global competencies for engineers [20]. Global engineering competencies have been suggested as part of global competencies only under the technical conditions that are the conditions of involving technical experts and/or technical problems [21]. G-DORM-approach based internships cover the abovementioned five attributes with regard to the technical conditions.

Capacity for solving revitalization issues using an integrated standpoint: The Niigata-based industry has a development history that has involved integrating new and various technologies as the surroundings changed. In such a context, internships conducted in cooperation with industrial companies in Niigata, which are based on the G-DORM approach, aimed to enhance problem-solving ability with an interdisciplinary approach as well as awareness regarding global technical or economic issues. In the case of industrial internships that tend to show less awareness of societal and community issues [22,23], the G-DORM approach encourages students to conduct a survey on global social and economic issues related to a real industrial problem. Furthermore, multi-disciplinary GWs were added to the approach with the aim of helping students develop a viewpoint for integrating knowledge from different fields in order to innovate a new solution.

Interests in the industry: An industry-based internship provides potential job opportunities [8]. Job matching is not a major purpose of the G-DORM project, but raising engineering students' interests with regard to the industry not only is vital for enhancing their career development but could also respond to a need for recruiting within the industry. The G-DORM approach thus provides students with opportunities to consider the strengths and weaknesses of the business operated by the hosting company; this can help students discover the attractive advantages of the given industry.

2.2.4 The Program Contents

The structure of the G-DORM approach consists of three learning phases: before,

during, and after the internship. It is well-known that motivation is a critical component of PBL and that a pre-study conducted before the internship is one major component of successful PBL internships. In particular, a problem targeted at the management of multi-cultural and multi-disciplinary PBL may result because of low-level English skills, lack of knowledge about science and technology, and a misunderstanding of participation motivation, since students may be unfamiliar with collaborative work with co-participants hailing from different countries and with different study backgrounds [24]. A PBL could increase students' confidence and motivation further if they had better awareness regarding the process for applied PBL [25]. To elicit the motivation of students for PBL, PBL's base design could include focused points with regard to learning strategies, groupings, the promotion of cooperation, and the setting of realistic goals [26]. Therefore, in the G-DORM approach, the pre-study includes reviewing the internship's learning objective, building a team of students, and enabling them to set their own goals that are to be achieved through the internship.

Hypothesis formulation is another important activity in the pre-study. In engineering problem solving, professional skills are often the analysis tools, and the goal is to solve the problem [27]. This approach differs from that of non-engineering PBL, where the problem is the analysis tool, and the learning is the goal. As an engineering education process, the pre-study in the G-DORM approach requires student groups to collect and absorb information related to the hosting company, to formulate a hypothesis aimed at producing a solution for the given company's problem, and to produce questions for verifying the hypothesis. During the last stage of the pre-study, students conduct a presentation session in order to gain feedback for elaborating on the hypothesis. The G-DORM approach allots two days for this pre-study.

The actual internship activity at the hosting company is conducted during the second phase. The hosting company provides lectures, factory tours, and work experience opportunities. Besides conducting group discussions, student groups also attempt to review and improve their hypothesis through consultations with the

company staff. Thus, in principle, students work under the direction of the company staff during the actual internship period. On their final day at the hosting company, student groups provide a presentation on their achievements, and, more importantly, suggest solutions for the hosting company's particular problems.

The third phase consists of the post-study, which is conducted after the internship. The post-study (lasting two days) includes the final presentation and a reflection workshop conducted on campus. The required contents for this presentation, which has a duration of 20 minutes, include answers to the following questions: 1) What activities did you/your group conduct and achieve during the internship? Please include a mission that was given by the company and describe your group's response to this mission; 2) What company-targeted challenges and/or suggestions did your group reveal?; 3) What experiences/lessons did you learn and/or gain through this internship?; and 4) Others (What other aspects of this experience—if any—would you like to emphasize?). The reflection workshop provides students with an opportunity to think about—and share—their significant learnings through the internship. After the reflection workshop, the participating students are required to submit a review report on any lessons they learned. In addition, each student is asked to use self-evaluation to measure personal performance.

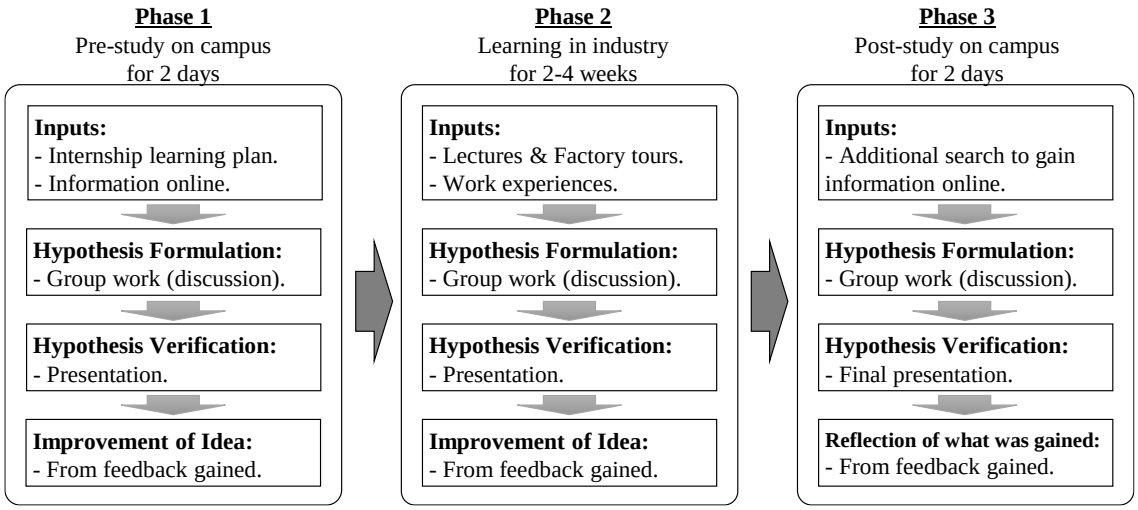


Fig. 4. The structure of the PBL programs in internships.

One feature of the G-DORM approach is conducting a presentation session and repeatedly providing feedback at the end of each phase (**Fig. 4**). This process provides recurring opportunities for the students to gain insights into industry-related knowledge, to conduct GWs for hypothesis formulation, to show presentations related to hypothesis verification, and to improve their ideas. This approach thus attempts to deepen their understanding of the hosting company and the related industry and also attempts to enhance their abilities including inter-lingual and inter-cultural communication, problem-solving, and presentation.

2.3 Methodology for Data Analysis

2.3.1 Target

This study's analyzed data included one case study—the medium-term and long-term programs conducted in AY2018 and AY2019 as part of the G-DORM project. The G-DORM project was launched in AY2016, and it initiated actual student exchanges among five universities in the following year [13]. After we could establish an appropriate data collection method and analysis through the initial practice, actual data collection was carried out in AY2018 and AY2019.

As a whole, 82 students were targeted in this study—37 from AY2018 and 45 from AY2019 (**Table 2**). Among the students, 40 visiting students had international travel experience, and almost the same number of host students (42) participated in an internship in their home country. Oda et al. [28] pointed out that language ability and international collaborative experiences effectively affected demonstrations of global teamwork skills in an international environment regardless of the participating students' nationality. As shown in **Table 2**, in this study, participating students' English skill levels were mixed. Furthermore, 27 students—about one-third of the students—had experienced participating in an internship in the G-DORM short-term program before; this could be described as an international collaborative experience.

Each hosting company designated the theme of the internship to tackle real-world issues—for instance, matters involving manufacturing site improvement,

social issues improvement, human resources, public relations, marketing, business policy proposals or a combination of these issues. The participating students had diverse specialties: mechanical engineering, electrical engineering, material engineering, chemical engineering, bio-engineering, food technology, information technology, computer engineering, aerospace engineering, civil engineering, architecture, and industrial engineering. Therefore, the students' groups were deliberately multi-disciplinary in nature, and the theme of the student groups' internship often differed from the students' specialties regardless of their requests.

Table 2. Description of the number of participating students in AY2018 and AY2019.

	Internships in lower Mekong countries		Internships in Niigata, Japan		
Demographics	Visiting students	Hosting students	Visiting students	Hosting students	Total
By academic year (AY) of internship					
AY2018	9	10	8	10	37
AY2019	14	13	9	9	45
By cumulative internship period					
1 month	19	23	13	19	74
2 months	4	-	4	-	8
By enrolled university					
RUPP (Cambodia)	-	4	3	-	7
NUOL (Laos)	-	4	3	-	7
CU (Thailand)	-	1	5	-	6
HUST (Vietnam)	-	14	6	-	20
NU (Japan)	23	-	-	19	42
By level of English skills					
Excellent	5	1	5	2	13
Good	15	12	5	12	44
Daily conversation	3	9	0	5	17
No official certificate	0	1	7	0	8
By G-DORM short-term internship experience					
No	20	21	6	8	55
Yes	3	2	11	11	27
Total	23	23	17	19	82

Notes: RUPP=Royal University of Phnom Penh, NUOL=National University of Laos, CU=Chulalongkorn University, HUST=Hanoi University of Science and Technology, and NU=Niigata University. The level of English skills of "Excellent," "Good," and "Daily conversation" corresponds to Test of English for International Communication (TOEIC) scores of 760+, 510-760, and 400-500 respectively.

2.3.2 Data Collection

Data regarding ***generic skills*** and ***global competencies for engineers*** were collected from students' responses to pre- and post-questionnaires for self-evaluation; these were designed to grasp changes in their self-perception with regard to the abovementioned skills and competencies. Our analysis applied 23 indicators from the "Completion Report of 2019-2020 JASSO Student Exchange Support Program (Short-term Study in Japan)" [29] to the collected data. Out of 23 indicators, 12, which were based on the FCWP, were regarded as generic skills, and the remaining 11 included key global engineering competencies suggested by scholars—for example, intercultural understanding, the ability to collaborate with foreigners, the ability to communicate with foreigners, and knowledge or interests with regard to social issues [19,20]. The questionnaire used a five-point Likert scale, where 1= Disagree, 2= Neutral, 3= Somewhat Agree, 4= Agree, and 5= Strongly Agree. The Japan Student Services Organization (JASSO) is a Japanese governmental organization that organizes the largest number of student exchange support scholarship programs in Japan. In this study, applying indicators established by JASSO made it possible to conduct a comparative analysis of the changes of students' self-efficacy against the Japanese general tendency to develop and enhance competence through study abroad programs; this has been reported by Kawaijuku, a contractor of the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan tasked with developing the report [30]. The response rate of the questionnaire was 100% (82/82).

On the one hand, data on ***capacity for solving revitalization issues using an integrated standpoint*** were collected from students' questionnaire responses only after their internship. The questionnaire focused on issues related to enhancing the ability to problem-solve with an interdisciplinary approach and awareness regarding global technical or economic issues. Furthermore, the questionnaire was used for collecting data on post-internship ***interests in the industry***, including the desire to find employment at the company, seeking more internships at the company, and maintaining a relationship with the company in the future. The questionnaire used the

yes/no question format. The questionnaire response rate was 96% (79/82).

Additionally, after the internship, a questionnaire was distributed to hosting companies in order to evaluate the students' performance; industry perceptions are meaningful for examining the correlations between learning purpose and student performance outcomes [22]. The questionnaire was used for collecting data related to ***generic skills*** and ***capacity for solving revitalization issues using an integrated standpoint***. Items regarding global competencies were excluded from the questionnaire, since some company staff could hardly understand foreign languages. The questionnaire applied a five-point Likert scale for evaluating students: 1= Could not do so, 2= Could not do so without instructions, 3= Could do so depending on contents, 4= Could do so, and 5= Could always do so. For students who participated in internships at multiple companies, scores were calculated by averaging the points obtained at each company. The questionnaire response rate was 100% (82/82).

2.3.3 Analysis Methods

The collected data were examined for general trends by calculating the mean of the points of the answers when the Likert scale was used or by calculating the percentage of the answers when the yes/no format was used. In addition, this study attempted to find specific trends in the changes in students' self-efficacy by examining not only the simple tabulation but also the cross tabulation of the mean or the percentage of the answers. A comparative analysis was conducted to find the differences between the pre- and post-questionnaire results. To prove the statistical significance of these differences, a paired t-test analysis was conducted by using the BellCurve for Excel (Social Survey Research Information Co., Ltd., Tokyo). A p-value of less than 0.05 was considered statistically significant in this study.

2.4 Results

2.4.1 Generic Skills and Global Competencies for Engineers

Overall, the results presented below show that ***generic skills*** and ***global competencies for engineers*** were enhanced by using the G-DORM approach. All the

means of 23 indicators (ID1.1 to ID1.12 for generic skills and ID1.13 to ID1.23 for global competencies for engineers) were increased in a comparison between the pre- and post-questionnaire (**Table 3**). In particular, all the means (except ID1.18) were statistically and significantly different at the 0.05 level after a paired t-test. Additionally, all the standard deviations of the post-questionnaire decreased from the figures indicated in the pre-questionnaire; thus, the students were able to perceive their competence more clearly compared to their perception before the internship.

Focusing on the mean of the post-questionnaire revealed that the study motivation for foreign languages (ID1.19, the mean=4.6) had the highest score; this was followed by the ability to communicate with foreigners (ID1.15, the mean=4.5) and intercultural understanding (ID 1.16, the mean=4.5). Thus, the key factors for global competencies for engineers received a high degree of self-evaluation from the students. In contrast, creativity (ID1.6, the mean=3.7) received the lowest degree of self-evaluation from the students. Looking at the evaluations of hosting companies, creativity (ID1.6, the mean=3.7) similarly received the lowest score, and planning skill (ID1.5, the mean=3.9), which was defined as the ability to independently find a solution for a problem and execute the solution, was also scored below 4.0.

Remarkably, the mean of all indicators for the post-questionnaire almost increased from the mean figure for the pre-questionnaire regardless of the characteristics (visiting or hosting) of the students or the location of the internship (**Fig. 5**). The concrete tendency of the mean in comparison with the data of 18,586 Japanese students under JASSO [30] was as follows:

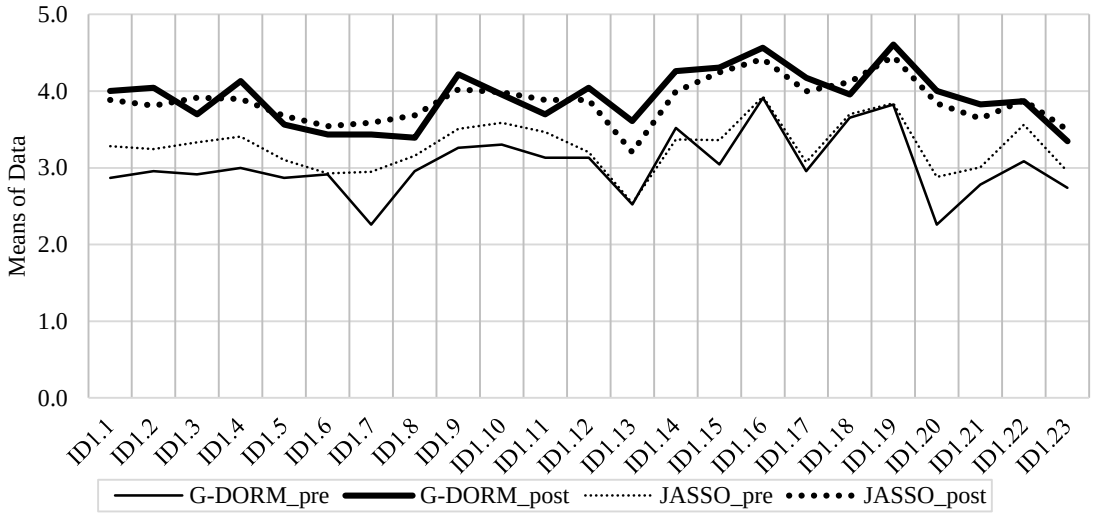
- The internships in the lower Mekong countries/of the visiting students; the tendency of the mean for each indicator of the post-questionnaire was comprehensively similar to the tendency of the JASSO, although one of the pre-questionnaires was lower than the that of JASSO. This indicates that the growth of the mean for each indicator in the G-DORM was higher.
- Internships in the lower Mekong countries/of the hosting students; the mean for each indicator of both pre- and post-questionnaires of the G-DORM was

higher than that of the JASSO. However, the growth of the mean for each indicator in the G-DORM was lower.

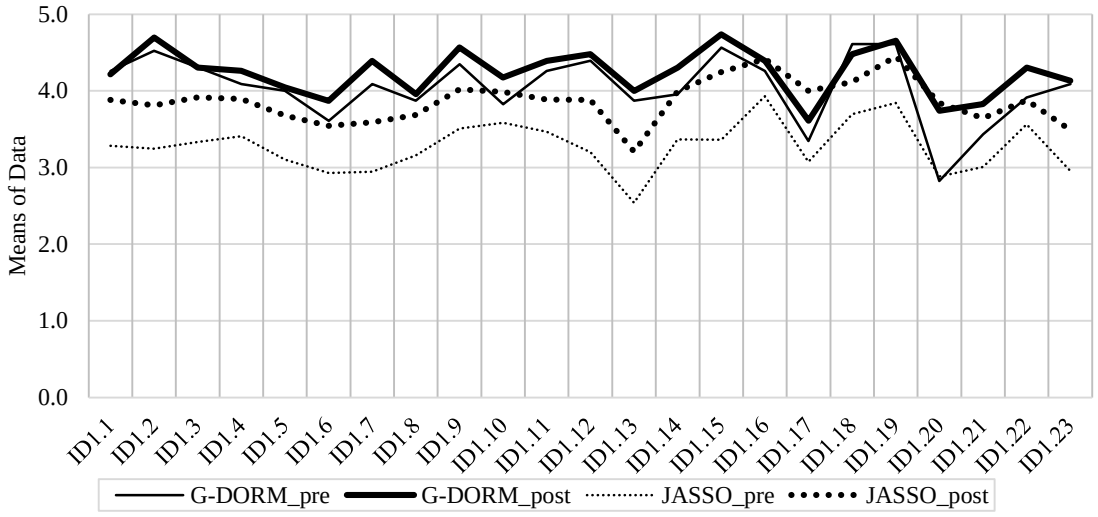
Table 3. The mean and standard deviation for the data from the pre- and post-questionnaires distributed to students.

		Pre-questionnaire (N=82)		Post-questionnaire (N=82)				
ID	Indicators	M	SD	M	SD	t-value	p-value	
1.1	Initiative	3.6	0.90	4.2	0.77	5.45	P < 0.001	**
1.2	Ability to influence	3.7	1.16	4.3	0.87	5.46	P < 0.001	**
1.3	Execution skill	3.7	1.02	4.1	0.88	3.99	P < 0.001	**
1.4	Ability to detect issues	3.5	1.00	4.1	0.70	5.82	P < 0.001	**
1.5	Planning skill	3.3	1.08	3.9	0.86	5.00	P < 0.001	**
1.6	Creativity	3.1	1.03	3.7	0.97	4.61	P < 0.001	**
1.7	Ability to deliver messages	3.2	1.32	3.9	1.07	4.96	P < 0.001	**
1.8	Ability to listen closely and carefully	3.3	1.08	3.8	1.04	3.81	P < 0.001	**
1.9	Flexibility	3.8	0.98	4.4	0.71	4.88	P < 0.001	**
1.10	Ability to grasp situations	3.6	0.87	4.3	0.77	6.49	P < 0.001	**
1.11	Ability to apply rules and regulations	3.8	0.94	4.1	0.89	3.28	0.0015	**
1.12	Ability to control stress	3.8	1.17	4.2	0.86	3.60	P < 0.001	**
1.13	Ability to collaborate with foreigners	3.2	1.11	3.8	1.01	4.77	P < 0.001	**
1.14	Challenging spirits	3.7	1.03	4.2	0.82	4.49	P < 0.001	**
1.15	Ability to communicate with foreigners	3.9	1.19	4.5	0.63	5.81	P < 0.001	**
1.16	Intercultural understanding	4.1	0.88	4.5	0.61	4.05	P < 0.001	**
1.17	Intercultural exchange experiences	3.4	1.35	4.1	1.07	5.74	P < 0.001	**
1.18	Study motivation for my major	4.1	1.01	4.2	0.91	1.77	0.0800	
1.19	Study motivation for learning foreign languages	4.3	0.87	4.6	0.63	2.87	0.0053	**
1.20	Knowledge regarding Mekong countries/Japan	2.5	1.19	3.8	0.94	10.78	P < 0.001	**
1.21	Knowledge or interests regarding Mekong/Japanese society	3.0	1.22	3.8	1.11	6.18	P < 0.001	**
1.22	Awareness of gender equality	3.7	1.17	4.1	1.02	3.13	0.0025	**
1.23	Future study and carrier design	3.3	1.26	3.8	1.18	3.84	P < 0.001	**

Notes: M=Mean, SD=Standard deviation ** : P<0.05



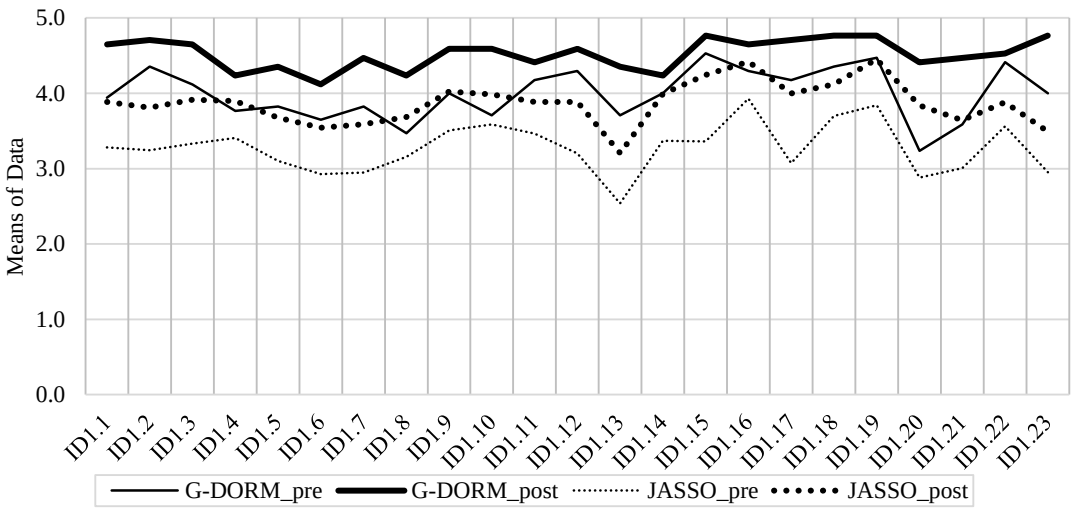
(a) Internships in lower Mekong countries/ Visiting students (N=23)



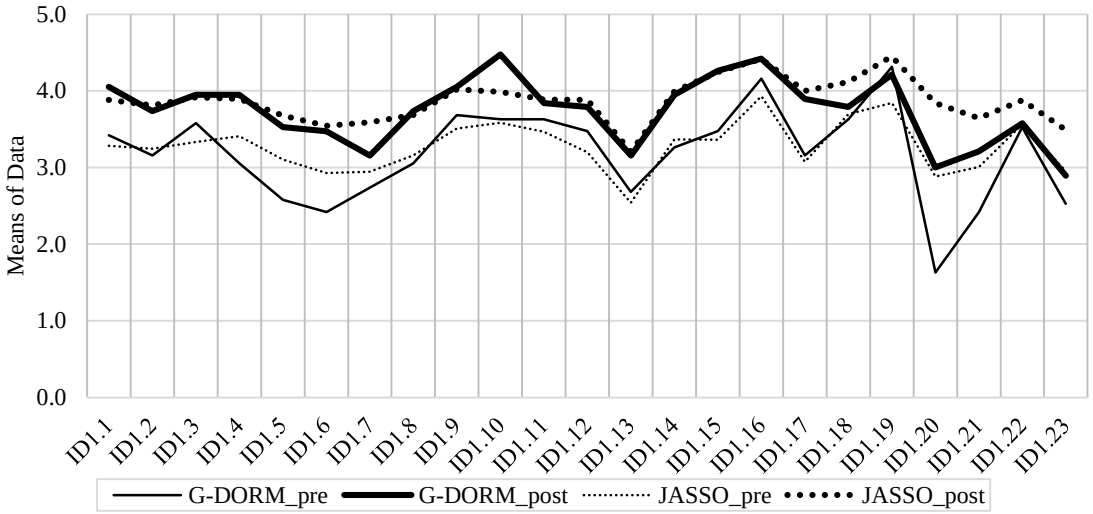
(b) Internships in lower Mekong countries/ Hosting students (N=23)

Notes: The data analyzed based on the characteristics of the students and the location of the internship, compared to the tendency of Japanese students (N=18,586), as determined based on data from JASSO [30].

Fig. 5. The mean of the data for the pre- and post-questionnaire distributed to students.



(c) Internships in Niigata, Japan/ Visiting students (N=17)



(d) Internships in Niigata, Japan/ Hosting students (N=19)

Notes: The data analyzed based on the characteristics of the students and the location of the internship, compared to the tendency of Japanese students (N=18,586), as determined based on data from JASSO [30].

Fig. 5. The mean of the data for the pre- and post-questionnaire distributed to students. (Continued)

- Internships in Niigata, Japan/of the visiting students; overall, the mean for each indicator of both pre- and post-questionnaires of the G-DORM was higher than that of the JASSO. Furthermore, the growth of the mean for each indicator in the G-DORM was higher.
- Internships in Niigata, Japan/of the hosting students; the tendency of the mean for each indicator of the pre-questionnaire of the G-DORM was lower than that of the JASSO. Focusing on the results of the post-questionnaire, the mean for the indicators regarding generic skills (ID1.1 to ID1.12) and one part of global competencies for engineers (ID1.13 to 1.17) almost reached the mean of the JASSO; however, the one regarding motivation for study (ID1.18 to ID1.19) and knowledge regarding lower Mekong countries and societies (ID1.20 to ID1.21) was much lower than the data of the JASSO.

In summary, overseas internships were found to have high effectiveness for enhancing perception regarding ability improvement. Furthermore, when the level of linguistic and cultural conditions in the internship was high, the students perceived their ability improvement more strongly.

2.4.2 Capacity for Solving Revitalization Issues using an Integrated Standpoint

This study focused on problem-solving ability with an interdisciplinary approach and awareness regarding global technical or economic issues as part of students' capacity for solving revitalization issues using an integrated standpoint. Regarding problem-solving ability with an interdisciplinary approach (ID2.1), there was a gap between students' evaluations and the hosting companies' evaluations (**Table 4**). The percentage of students who noticed an increase in their ability to identify solutions by integrating crucial knowledge and technology for concrete problem-solving (ID2.1) reached 77% (61/79). However, the mean of the related item that was graded by the hosting companies was 3.7 (=less than 4.0); that is, the hosting companies recognized the insufficiency of the students' performance. Regarding the recognition of increases in their ability to identify global technical or economic issues in

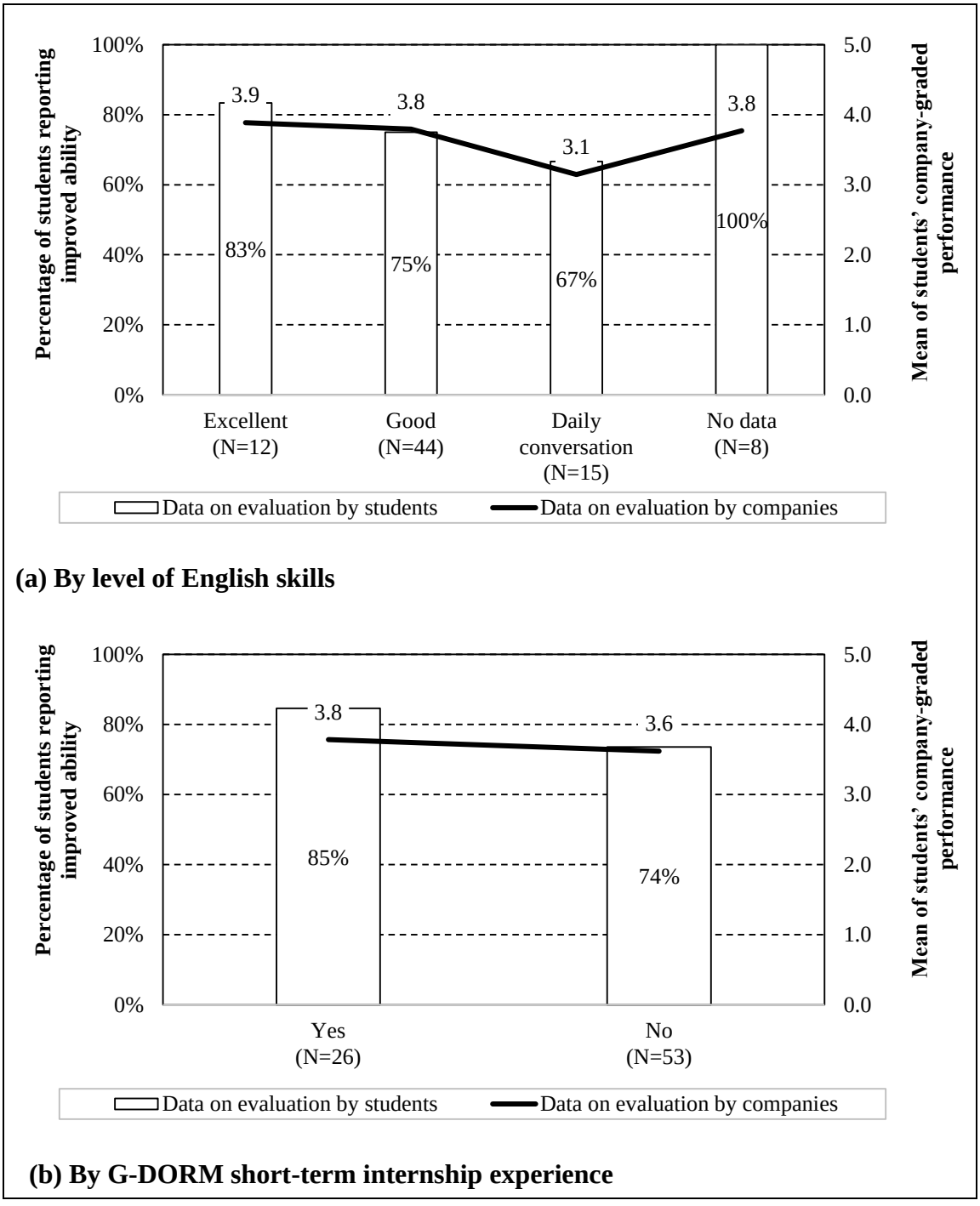
industries in order to expand businesses in the Mekong (ID2.2), students' self-efficacy was low (the answer rate=32%, 25/79) as well as the hosting company evaluated with the low score (the mean=3.7). In addition, the hosting companies' evaluations for knowledge regarding the strengths and weaknesses of the company/related industry (ID2.3, the mean=3.8) and for knowledge regarding the theories and technologies of the company (ID2.4, the mean=3.6) was also scored below 4.0.

Table 4. An evaluation of the capacity for solving revitalization issues from an integrated standpoint.

ID	Items	Evaluation by students	Evaluation by companies
	N	79	82
2.1	Problem-solving with interdisciplinary approach	77%	3.7
2.2	Awareness regarding global technical or economic issues	32%	3.7
2.3	Knowledge regarding technology of the company	-	3.8
2.4	Knowledge regarding advantages in the company/related industry	-	3.6

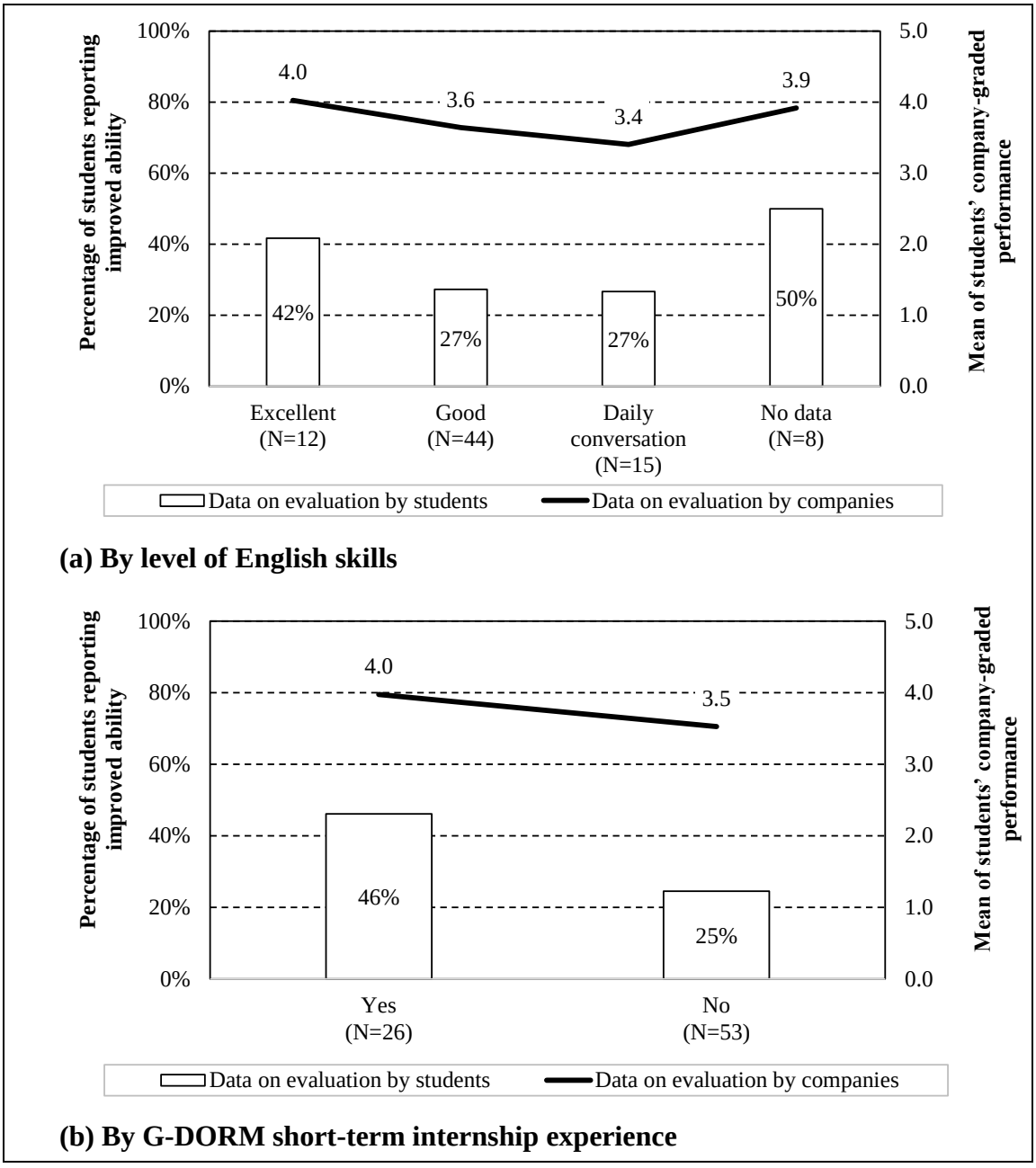
Notes: The data on the evaluation by students show that the percentage of those who answered that their ability of each item had improved after the internship, and the data for the evaluation by companies showed the mean of students' performance graded by the companies.

There was another notable finding—namely, foreign language skills and the G-DORM short-term experience affected the output of the medium- and long-term internships positively. Evaluations by both students and hosting companies with regard to problem-solving ability with interdisciplinary approach (ID2.1) demonstrated greater positive results when students had English skills and experienced the G-DORM short-term internship before (**Fig. 6**). The results for ability to show awareness regarding global technical or economic issues (ID2.2) showed a similar tendency **(Fig. 7**).



Notes: The data on evaluation by students showed the percentage of those who answered that the ability had improved after the internship, and the data for the companies' evaluation showed the mean of the students' performance graded by the companies.

Fig. 6. Evaluating problem-solving with interdisciplinary approach (ID2.1) based on level of English skills (a) and G-DORM short-term internship experience (b).



Notes: Data on the students' evaluation showed the percentage of those who answered that the ability had improved after the internship, and data on the companies' evaluation showed the mean of the students' performances graded by the companies.

Fig. 7. Evaluating awareness regarding global technical or economic issues (ID2.2) based on the level of English skills (a) and the G-DORM short-term internship experience (b).

2.4.3 Interests in the Industry

Internships with the G-DORM approach helped to raise the interests of students with regard to hosting companies and the related industry as well (**Table 5**). After the internship, 77% (61/79) of the students showed interests in the company/industry (ID3.1). The percentage of students who answered that they sought to obtain a job with the hosting company (ID3.2) reached 28% (22/79). Of the 22 students, 19 students (86%) expressed interests in the hosting company; thus, there was potential to create a demand from this interest. Curiously, 48% (11/23) of the hosting students who joined internships in the lower Mekong countries expressed a demand for obtaining a job with the hosting company, while the percentage of those having interests in the company/industry was 65% (15/23), which was the lowest. The results also showed that students from the lower Mekong countries showed a higher percentage of ID3.2, ID3.3, and ID3.4 compared to the students from Niigata.

Table 5. The percentage of students who enhanced their interests, demands, or motivations regarding hosting companies after their internship.

		Internships in lower Mekong countries		Internships in Niigata, Japan		
ID	Items	Visiting students	Hosting students	Visiting students	Hosting students	Total
	N	22	23	17	17	79
3.1	Interest in the company/industry	73%	65%	88%	88%	77%
3.2	Demand for obtaining a job with the company	18%	48%	29%	12%	28%
3.3	Demand for participating in more internships in the company	18%	22%	29%	12%	20%
3.4	Demand for maintaining a relationship with the company	50%	57%	88%	41%	58%
3.5	Motivation to buy products/services from the company	36%	26%	29%	24%	29%
3.6	Motivation to disseminate the values of the company	45%	39%	59%	88%	56%

2.5 Discussion

This chapter's main objective was to argue the effectiveness and challenges of multi-cultural and multi-disciplinary PBL in the industry; this was achieved through an examination of case studies of internships that utilized the G-DORM approach.

The current research is still at the starting point and may have some shortcomings. However, we found an enormous possibility for the G-DORM approach to foster globally competent engineers as follows.

Generic skills: Our findings demonstrated the G-DORM approach provides a positive impact on generic skills. The results showed that the mean for all 12 indicators of the students' post-evaluation figure regarding the FCWP increased from the pre-evaluation figure regardless of the characteristics (visiting or hosting) of the students or the location of the internship. This agrees with previous research findings in the practice of engineering internships for enhancing generic skills; some of these studies include Lopes et al. [12] and Haag et al.[22]. However, evaluations for creativity (ID1.6) and planning skill (ID1.5) were low; thus, improvements in the competencies will be a future challenge.

Global competencies for engineers: The study results highlighted the effectiveness of the G-DORM approach for enhancing global competencies for engineers. In particular, students' self-efficacy with regard to communication with foreigners (ID1.15) and intercultural understanding (ID1.16), which are highly graded competencies for global engineers, must be raised through internships. This matches previous literature findings regarding the effectiveness of multi-cultural PBL for enhancing global competencies such as Voronchenko et al. [4] and Brennan et al. [5]. Our results have the advantage of indicating the effectiveness of the practice even in an industry with a real-world problem.

The study results emphasized that, when the internships had a higher level of linguistic and cultural conditions, the students perceived improvement in their ability more strongly. In particular, the superiority of an internship abroad for enhancing self-efficacy in terms of global competence was confirmed. The G-DORM approach demonstrated key competencies for global engineers, including communication, cultural difference appreciation, and teamwork (ID1.13 to ID1.17), even without international travel. However, the study results also indicated a weakness in enhancing knowledge about overseas policy, ethics, and society (ID1.20 to ID1.21) without international travel. Downey et al. [2] suggested the importance

of establishing an engineering course for improving global competence even without overseas travel in order to reduce the barriers posed by a study abroad requirement. This indicates that the G-DORM approach can provide an effective way for enhancing engineers' global competencies by transferring students' roles from participating as host students to that of visiting students. This could pose a future challenge for reducing the barriers faced by hosting students with regard to international travel.

Capacity for solving revitalization issues using an integrated standpoint: Regrettably, the study results showed that companies' evaluations for problem-solving with interdisciplinary approach (ID2.1) and awareness regarding global technical or economic issues (ID2.2) were relatively low. Even despite this fact, however, a key finding was that English skills as well as the G-DORM short-term experience helped to enhance evaluations of these abilities from both students and hosting companies. This tendency is consistent with that observed in a previous case study by Oda et al. [28]. Thus, the effectiveness of the G-DORM approach can be increased through repeated participation—that is, participation in short-term to medium-term programs.

The study results also showed fewer students acquired knowledge regarding technology in a given company (ID2.3) or knowledge regarding advantages in the company/industry (ID2.4). Thus, the hosting companies may have believed that the students had not been able to grasp the company's issues or solutions based on the theory and technology of the company. A critical point to consider here is whether students could have acquired the required knowledge before a PBL internship, since the PBL internship hardly created any impact on knowledge acquisition [31–33]. Furthermore, the intervention of a moderator could have supplemented students' lack of knowledge during PBL [34,35]. Therefore, optimizing the period of the internships, the pre-study, and the intervention of faculty members as moderators will be future challenges for students' knowledge acquisition methods.

Interests in the industry: The results demonstrated that more than three-fourths of the students expressed interest in the company or its related industry (ID3.1) after

their internship in spite of the fact that their specialties were almost always different from the theme of the internship. Thus, the G-DORM approach was proved to effectively raise students' interests in the industry.

The results also showed that some students expressed a demand for further actions that would help them interact with the company more closely—for example, obtaining a job (ID3.2) or additional internships at the company (ID3.3). In particular, the percentage of students from lower Mekong countries who expressed a demand for obtaining a job with the company was higher than that of Japanese students who expressed similar demands; this was the case despite the fact that multi-cultural conditions were harder for the students from lower Mekong countries. Students from lower Mekong countries would have demanded opportunities to maintain a relationship with the hosting company from the standpoint of career development. However, further data collection is necessary for determining exactly how an increase in interests affects willingness to maintain a relationship with the company.

At the very least, this study's findings implied the importance of a post-study for promoting metacognition for their interests toward future actions for their career development. From a career development standpoint, the G-DORM approach can provide students with an opportunity for planned happenstance, as was suggested by Mitchell et al. [36], since the theme of the internship differed from the requests of the students. Metacognitive and planned happenstance perspectives can significantly enhance students' self-concept, motivation, time management, and ability to solve learning problems [37]. Based on these previous studies, one of the assumptions is that the improvements in the post-study activity based on the Happenstance Learning Theory advocated by Krumboltz [38] could increase the effectiveness of the G-DORM approach. Further studies are needed in order to confirm this assumption.

Lastly, internships can help to maintain university-industry partnerships. In particular, in newly industrialized countries, emerging industries' interventions in higher education fields before students' graduation is a key factor for aiding

industries in gaining knowledge about universities [39]. The G-DORM approach, which proposes solutions for resolving real-world problems through education, could lead to not only the fostering of global Sci-tech leaders but also the enhancing of industry-university collaborations and support for industries in lower Mekong countries, especially with regard to resolving their issues. This issue is also reserved for future work in this research direction.

2.6 Conclusions

Internships using the G-DORM approach as a multi-cultural and multi-disciplinary industry-level PBL could positively affect students' global engineering competencies. In fact, the study results emphasized the effectiveness of the G-DORM approach for enhancing generic skills as well as global competencies for engineers. This study's evidence indicated the importance of improving foreign language skills as well as the usefulness of designing stepping-up programs for developing competence (for example, short-, medium-, and long-term or domestic to international programs). Furthermore, this chapter has suggested the optimization of the internship period, the pre-study, and the intervention of moderators during the internship for enhancing learners' capacity for solving revitalization issues using an integrated standpoint. This chapter has also suggested the importance of post-study for promoting the metacognition of learners' interests in the industry with the aim of influencing their future actions for developing their competence levels and careers. Further studies, which take the above suggestions into account, will need to be performed for this purpose.

This study may have some possible limitations. Since this study still dealt with only 2-year practices, the number of students may not be sufficient for analyzing the correlation between students' self-efficacy and the combination of the theme of the internship and students' grades or specialties. If this is revealed, we can make a more effective internship program with the G-DORM approach.

CHAPTER 3
CASE 2: SHORT-TERM INDUSTRIAL EXPERIENTIAL LEARNING

3.1 Introduction

In globalization, many scholars pointed out that engineering education had to enhance students' competence for carrying out his/her business demonstrating expertise and technical skills in the real world [1]. In particular, a challenge of engineering education in higher education is to respond to engineering problems in society, thus, education at universities has been expected as readiness for working at companies after graduation. The main approaches for it are indicated as: to reform the curriculum with more practical-oriented training; to adopt problem-based learning, project-based learning (PBL), and the like; and to strengthen the partnership between university and industry [40]. In fact, it is indicated that multi-disciplinary and multi-national PBL through university-industry collaboration was useful to foster global teamwork skills [23]. Also, regardless of the nationality of students, language ability and international collaborative experiences effectively affect the demonstration of global teamwork skills in an international environment, thus, providing working opportunities is recommended [28]. On the other hand, a previous study showed a challenge on how the interests of students in social issues could be enhanced, in case a global PBL with companies gave the students assignment that was to propose a solution for a real-world problem [23]. Industrial experiential learning is an effective way for this.

The G-DORM project, which is a bilateral students' exchange project between universities in the lower Mekong region and Niigata, Japan, has had a short-term program in Tsubame City, Niigata, every year since 2017. The short-term program has been conducted with Tsubamate, a non-profit organization that works to promote industrial development in the city. Tsubame City is well known as one of the famous industrial clusters in the field of metal processing in Japan. The short-term program in the topics of manufacturing technology aims to enhance knowledge on and interests

in technology for supporting industries, which is a challenge in the lower Mekong countries. It also aims to foster students' competency for global sci-tech leaders such as English communication and intercultural understanding, as well as problem-solving, interdisciplinary points of view, and global teamwork through group activities of multinational and diverse students. Thanks to the cooperation of the regional industry, all the students could stay at the same dormitory while they learned in Tsubame in AY2019 so that they could have international communication regardless of day and night. Eventually, the short-term program won the “Award of Excellence” in the 3rd “Internship Awards Selected by Students” organized by Mynavi Corporation in May 2020, thus, this attracted not only stakeholders of the project but also nationwide in Japan [41].

Knowledge gained and lessons learned from practices of global or multi-cultural and multi-disciplinary PBL in university-industry collaboration have not been compiled enough for engineering education research, and sharing it would be needed [23]. This chapter presents the contents including efforts by the regional industries for its implementation, and the achievements of the short-term industrial experiential learning carried out in Tsubame City in AY2019 in terms of students’ satisfaction and interests in the regional industry.

3.2 The Pedagogical Approach

3.2.1 The Learning Purpose

A key to PBL in engineering education to make it productive learning is to set a real-world problem in the industry as a mission for students to solve in the PBL [27]. According to Tsubamate, Tsubame industries possess high skills for metal processing whose products impact around the world, however, many regional companies have the weaknesses such as not enough for the introduction of Internet of Things (IoT) and/or Artificial Intelligence (AI), lack of successors of the professionals, and the working environments not improved. Thus, challenges for sustainable development of Tsubame industry are to find a solution to the questions such as “what are values of industries/companies in Tsubame, valid for future in further globalization?” and

“What are measures to solve problems by Information Technology (IT) for the future sustainable development of industries/companies in Tsubame?”

Giving the above, the learning purpose of the short-term program in AY2019 was set as follows: To understand the development process and current status of industries/companies in Tsubame, which is one of the famous industrial areas for metal processing in Japan, on the basis of international relations (international extension and/or international competitiveness, etc.). In addition, to suggest challenges and its solution for sustainable development of Tsubame industries towards the future. In particular, the program focuses on suggesting a solution for solving the problems in terms of IT promotion.

3.2.2 The Program Contents

The short-term program conducted from August 21st to 30th in 2019, which consisted of eight working days and two holidays (**Table 6**). To achieve the learning purpose, the short-term program applied to the following three steps: Step 1 was 2-day activities at the university before visiting Tsubame. On the first day, the students received a briefing about the learning purpose and the schedule of the program. Also, a team-building activity was carried out. On the second day, GW was conducted to learn materials on the activity plan while visiting the company, to build a hypothesis about a solution to the problem at the company, and to make questions to verify the hypothesis. Consequently, a presentation session was held to share the result of the GW in each group. Step 2 was the learning in the industry during the stay in Tsubame for four days. On the third day, as a joint activity in Tsubame, the students learned the history of Tsubame industry as well as the vision for the promotion of IT through the observation of Tsubame Industrial Materials Museum and the lecture by the staff of Tsubame municipality. For three days on the fourth to the sixth day, the students separated into six companies practically to learn technology which the industry in Tsubame possessed through working experiences, then they discussed their proposal to solve the problems each company faced. In the afternoon on the sixth day, the students were assembled at one place to present their proposal towards sustainable

industrial development in Tsubame as a joint presentation session of the six companies. Step 3 was the final presentation and the reflection workshop at the university. The seventh day was for GW to prepare a presentation. The final presentation in the forum was held in the morning on the eighth day. In the forum, each students' group required to provide an English presentation. Each Group had 15 minutes for the presentation to be given and 5 minutes for Question and Answer (Q&A) in the forum. Then, a workshop to reflect their learning and share it was conducted in the afternoon on the same day.

Table 6. Learning goals on each day in the G-DORM short-program in AY2019.

Step	Date	Summary	Learning Goals
Step 1	Aug 21	Orientation	Build and develop relationships among group members. Understand the main business of the company to be visited.
	Aug 22	GW for Pre-study	Understand the contents of GW internship at the company and create questions to ask the company, considering the contents of GW internship.
Step 2	Aug 23	Tsubame Day1	Understand the development process and current status of Tsubame industries, especially in terms of IT promotion.
	Aug 24-25	Saturday and Sunday	Gain opportunities to participate in a street event in Tsubame and exchanges with the locals and students deeply.
	Aug 26-28	Tsubame Day2-4	Understand the values and challenges of the company through an internship. Consider and propose answers to respond to the mission assigned.
Step 3	Aug 29	Presentation Preparing	Prepare for an English presentation.
	Aug 30	Forum and Reflection	Provide an English presentation in the forum. Identify lessons learned for future study and career, reflecting activities.

As an assignment to students, the contents of the final presentation were required to include as below;

(1) Past and current status of industries in Tsubame (Leanings mainly from activities on Aug 23): to show "Strengths and weaknesses of industries/companies in Tsubame" in terms of industrial clusters (relation/network among companies in Tsubame), international relations (international extension and/or international

competitiveness, etc.), and/or IT promotion. That shall be shown on the basis of the development process and the current status of the industries/companies (past and present of the industries/companies).

(2) Activity report on industrial experiential learning (Learnings mainly from activities on Aug 26-28): to show the mission assigned by the company where your group visits for the industrial experiential learning and suggestions of your group to respond to the mission. Also, to show its reasons based on facts (contents of and findings through the industrial experiential learning).

(3) Suggestions on sustainable development of Tsubame industries towards future (Suggestions based on the learnings from activities on Aug 26-28): to propose "values of industries/companies of Tsubame, valid for future in further globalization (unique values of industries/companies that can be valid for future domestically and internationally, especially in Asia)" and "concrete measures of problem-solving by IT technology for the future sustainable development of industries/companies in Tsubame". The values and measures shall be suggested in relation to each other. Also, to show its reasons based on facts (contents of the above (1) and (2)).

(4) Your own lessons learned (Capacity building by the short-term program): to show your own lessons learned through the program, and your idea of how you would like to utilize the lessons learned for the future.

A feature of the short-term industrial experiential learning as a PBL was to conduct a session of presentation and give its feedback repeatedly at the end of each step (**Fig. 8**). This provided opportunities repeatedly for the students to have inputs about knowledge on the industry, GWs for hypothesis building, presentations liking hypothesis verification, and revision of their ideas. It attempted to deepen their understanding of the companies and industries as well as to gain skills such as inter-lingual and inter-cultural communication, problem-solving, and presentation skills. This three-step learning methodology was also applied to the PBL internships in the G-DORM medium- and long-term programs likewise (please refer to **Fig. 4.** The structure of the PBL programs in internships.).

As mentioned above, the three-step learning methodology could help to enhance students' understanding of the regional industry. The program provided opportunities to learn the strengths and weaknesses of technology and/or services which the company possessed through an investigation study on the regional industry and the company from the pre-study stage. Then, while visiting the company, students' understanding about the work of the visiting company was promoted through a three-stage approach: a lecture on the business of the company, practical experience of the business of the company, and presentation to propose a solution for a real problem the company faced and to get feedback from the staff of the company. Not only a presentation at each company but also a joint presentation session of the six companies were organized to share students' lessons learned from the company.

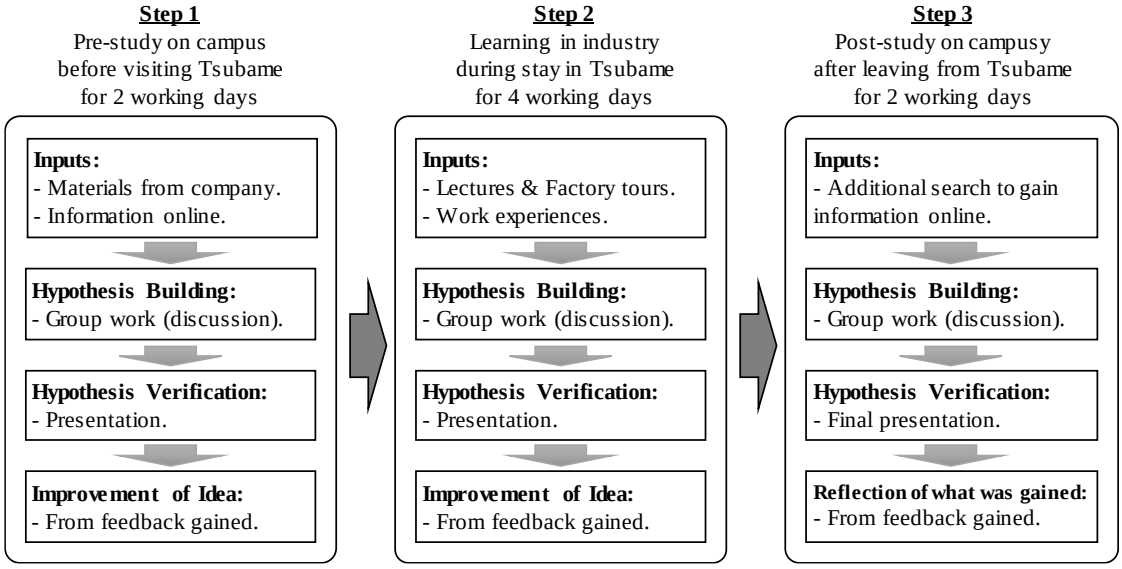


Fig. 8. The structure of the short-term industrial experiential learning as PBL.

The short-term program promoted active exchanges among students and the staff of the companies thanks to the companies' cooperation. During activities at each company, the students could get advice on the internship and their future career, exchanging with the staff of the company through a lecture of the business, a factory tour, and working experiential of manufacturing. Some companies attempted to

develop a further relationship with students by having lunch together. In addition, Tsubamate organized a banquet to deepen the exchanges among stakeholders, such as foreign students, students and faculties of the host university, the staff of the administrative office in charge of industrial development including the mayor, and the staff of the companies accepting the internship. For the industry sector in the city, this became a good chance as an activity of international exchange. One of the distinguished functions of Tsubamate is the management of a guesthouse that students can stay. Thus, the students stayed at the guesthouse and could get advice from and consult with the staff of Tsubamate. The guesthouse was located in the central area of the city, and on the holiday, a street festival was held on the road in front of the guesthouse. The staff of Tsubamate invited the students to the street festival as an opportunity to experience Japanese local culture as well as to interact with local people and the industries.

After the short-term program, the students were required to submit a report to review their lessons learned. Also, the self-evaluation by the students were asked to measure the performance of the students by this learning. The indicators for the evaluation utilized some questions in the “Completion Report of 2019-2020 JASSO Student Exchange Support Program (Short-term Study in Japan)” [29].

The short-term industrial experiential learning in the program was designed to meet elements required for "internship as a formal curriculum" that had been established by MEXT in 2018 [42]. Since this 1) had working experiential learning, 2) was a credit-certified program in the formal curriculum, 3) allocated opportunities for instructing students appropriately, 4) had a system of learning evaluation after its implementation, 5) was a program whose period was five days or more including pre- and post-study, and 6) was carried out in collaboration with companies.

3.3 Methodology for Data Analysis

3.3.1 Target

This study's analyzed data included one case study of the G-DORM short-term program in AY2019 conducted a PBL with six companies in Tsubame City to solve

the issues provided by each company. Six groups which consisted of 17 students from the four countries such as Cambodia, Laos, Thailand, and Vietnam (hereafter called as foreign students) and 11 students from Niigata University (hereafter called as host students) tackled the issues as GW. The major of the students was diverse such as mechanical engineering, electrical engineering, material engineering, chemical engineering, bio-engineering, food technology, information technology, human science, and engineering management. The groups were composed, considering the balance of the academic year, major, nationality, and gender (**Table 7**). During visiting Tsubame, one NU student with high English skills was additionally assigned as a communication supporter to each group to help English communication between the staff of companies and students.

Table 7. Group composition in the G-DORM short-term program in AY2019.

Group #	1	2	3	4	5	6	Number of persons
RUPP (Cambodia)	F2	F2	F3	-	-	F2	4
NUOL (Laos)	F2	F3	-	M3	M2	-	4
CU (Thailand)	-	-	F3	M3	M3	F2	4
HUST (Vietnam)	-	F1	M1	F3	F4	M_D3	5
NU (Japan)	M3	M3&M1	M3&M1	M3&F1	M2&F2	M4&M2	11
Number of persons	3	5	5	5	5	5	28

Note: M=Male, F=Female. The number following M or F means academic year. D3 means a 3rd-grade doctoral student.

3.3.2 Data Collection and Analysis Methods

This study conducted a questionnaire survey to verify the evaluation of the satisfaction of the students and the enhancement of the students' interests in the industry after the program. The target of the questionnaire was all students, a total of 28 students. The questionnaire response rate was 100% (28/28).

The collected data were examined for general trends by calculating the percentage of the answers.

3.4 Results and Discussion

3.4.1 Students' Satisfaction

The overall evaluation of the internship was positive, thus, all foreign students and 90% or more of host students evaluated the internship comprehensively as "Excellent" or "Good", and nobody answered “Below Average” nor “Poor” (**Fig. 9**).

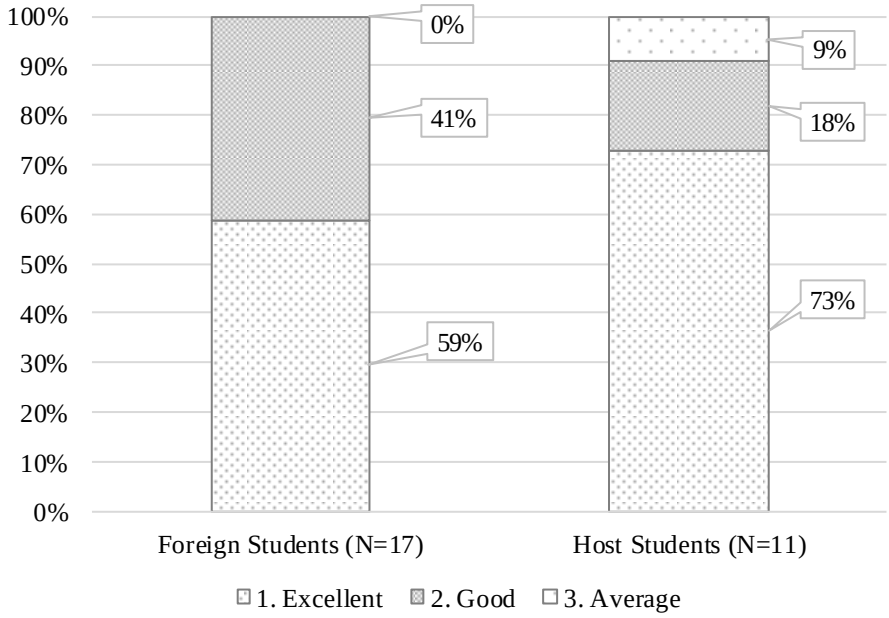


Fig. 9. How do you evaluate the short-term program comprehensively?

One of the features of the practice in AY2019 was that the foreign and host students stayed together in the same guesthouse during their visiting Tsubame City, as a literal “Global Dormitory”. It helped them to have exchanges day and night. Regarding students’ satisfaction with it, over 90% of both foreign and host students answered that they were “Very satisfied” or “Satisfied” (**Fig. 10**). The exchanges day and night could have become a valuable opportunity for both students who had less chance of international exchanges to have cross-language and cross-cultural communication as well as to develop close friendships. In the reflection workshop conducted on the final day, many groups mentioned that what had been the most significant changes for them through the short-term industrial experiential learning were the improvement of English or intercultural communication, friendships closer, and so. After the program, the students continued their communication and

friendships via social networking service (SNS), and some actually met again across the national border.

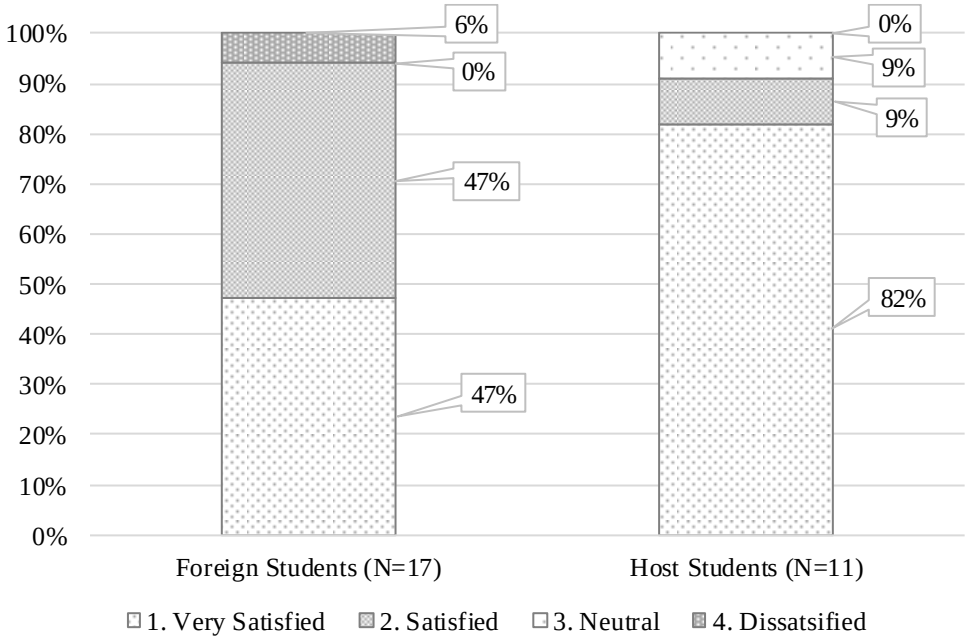


Fig. 10. Do you satisfy to stay a guesthouse with students mixed multi-nationally?

3.4.2 Interests in the Industry

The short-term industrial experiential learning could raise students' interests in the industry since 94% (16/17) of foreign students and 91% (11/10) of host students answered that they had "increased" his/her interests in the regional industry (ID3.1), showing the effects regardless of nationality (**Fig. 11**).

The results also showed that students from the lower Mekong countries showed a higher percentage of ID3.2, ID3.3, and ID3.4 compared to the students from Niigata. This tendency is similar to the result of Case 1: the medium-term and the long-term programs. Remarkably, 65% (11/17), more than half of the foreign students expressed a demand for participating in more experiential learning in the company, while the percentage of those of the host students was 18% (2/11); however, of the 11 host students who had participated in the short-term program conducted in Tsubame City, one subsequently participated in the mid-term program in

Niigata and one participated in the overseas medium-term program. In addition, seven students had been determined to participate in a short-term overseas program, which was originally scheduled from February to March in 2020 and was eventually canceled due to the risks of spreading the coronavirus disease 2019 (COVID-19). Similarly, of the foreign students who had completed the short-term program conducted in Tsubame City, one foreign student participated in a medium-term program after returning to her home country. Also, three students had determined to participate in a short-term program in their home, which was eventually canceled due to the COVID-19.

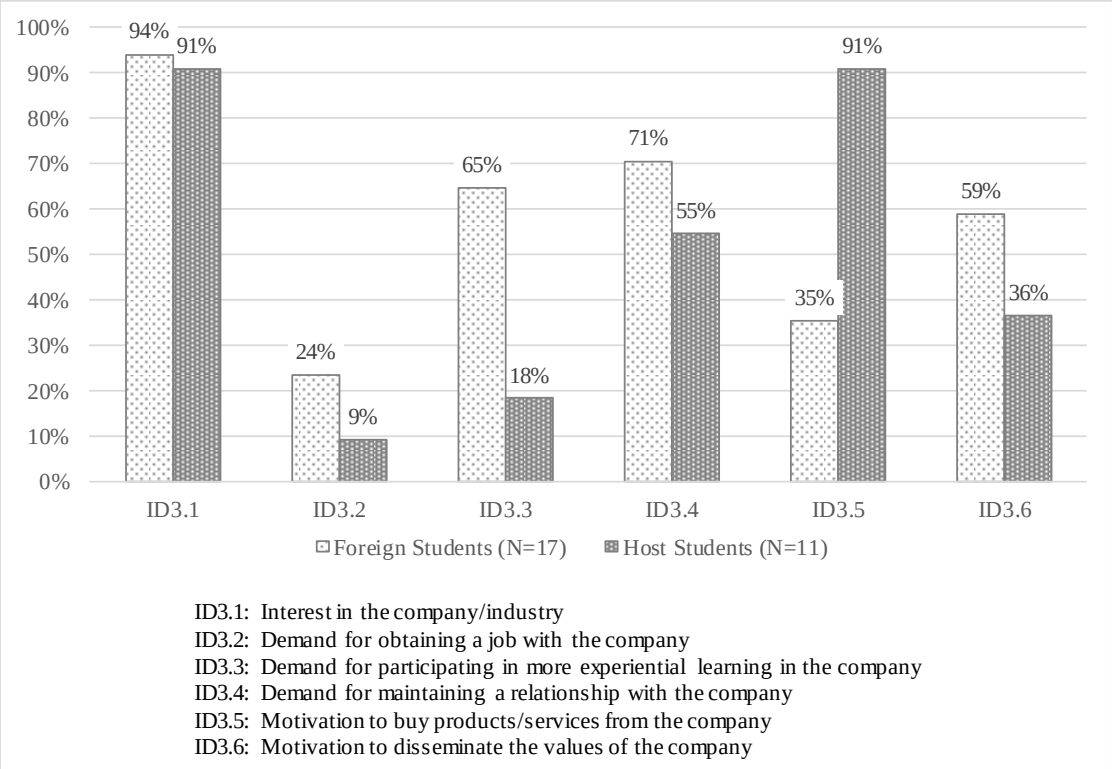


Fig. 11. Whether interests in regional industry did you increase?

These results indicate the short-term industrial experiential learning could enhance further learning motivations of students for a new challenge of stepping-up learning such as learning from a domestic program to an overseas program, or from a short-term to a longer-term program. Thus, it has provided the effectiveness of the

short-term industrial experiential learning which has the high possibility to promote for students to take on a step-by-step learning approach.

3.5 Conclusions

This chapter describes the pedagogical approach of the industrial experiential learning in the G-DORM short-term program in Tsubame City practiced in AY2019, and showed the results mainly in terms of students' satisfaction and interests in the regional industry. The GW internship resulted in the high satisfaction of the students and raised their high interest in the regional industry as well as enhanced their friendship globally, regardless of their major nor nationality. It also developed the motivation and the actual action of students in a step-up tendency towards such as a longer-term program or an overseas program. This would come from much effort of the regional industry to attempts to enhance students' interests through providing opportunities for PBL based on real-world problems and active exchanges including the international guesthouse as Global-Dormitory.

Thus, this study results demonstrated the high possibility that industrial experiential learning is a beneficial method of engineering education that can be the entry point to promote education for better understanding and realization of how to connect with society such as industry and overseas.

CHAPTER 4
CASE 3: LECTURE COURSE

4.1 Introduction

For engineering, it is important to understand the needs of society, to search for undiscovered issues, to find useful issues for society, and to predict and know what is necessary for a sustainable society [43]. In 2015, “the 2030 Agenda for Sustainable Development” was adopted by the United Nations, and Sustainable Development Goals (SDGs) were defined as 17 goals to improve global social issues. In addition, the Government of Japan proposed “Society 5.0” as a growth strategy based on the development of science and technology. Furthermore, the Japan Business Federation (Keidanren) advocated “Society 5.0 for SDGs” as a concept of promotion and contribution for sustainable development through technological innovation. In that background, it was pointed out as challenges to innovate engineering education for the development of individuals required in the 4th Industrial Revolution, the ultra-smart society (Society 5.0) or in future of the society [44]. In particular, SDGs and Society 5.0 should be considered when fostering engineers responsible for the future in globalization [45]. In fact, one of the key messages on the first World Engineering Day (March fourth, 2020) is “Engineering plays a key role in achieving the SDGs” and for this “It is also crucial to the development of new technologies enabling the 4th Industrial Revolution”[46]. On the other hand, technological innovations like Information and Communication Technology (ICT) and progress in globalization made engineering required to develop human resources capable of creating values in collaboration globally with diverse entities across the academic fields [47]. In such a context, one of the challenges is to develop ways of active learning and to share lessons learned from its practices that are effective for human resource development aiming at building capacity for general competencies such as creativity and teamwork leading to innovation [48].

The author practiced active learning for multinational students to think about global engineers including a GW on SDGs and Society 5.0 in the lecture course

“Topics in Global Science and Technology” at NU in AY2018. This chapter aims to argue the achievements of this practice.

4.2 The Pedagogical Approach

4.2.1 The Learning Purpose

The lecture course “Topics in Global Science and Technology” dealt with various global topics in the field of science and technology and was lectured by the author, a faculty with practical experiences at home and abroad on international cooperation, community development, and emergency response and recovery in disasters. These topics were explained in plain English, and learners were required to have active participation in English discussion on the topics as active learning. The topics were related to (1) Japanese Society from Overseas Standpoint, (2) Disasters in Japan and Engineering, Science and Technology, (3) SDGs for Science, Technology and Innovation (STI), (4) Development of Science and Technology, and Future Vision, and (5) International Cooperation and Global Career. As mentioned above, the ability to connect science and technology into sustainable development is required for playing an active part in a global society as an engineer or technician in the future. Problems for sustainable development are diverse and have cross-cutting relations; therefore, it is required to have the following points for solving the problems: to recognize a diverse sense of value beyond the expertise of the learner, to gain comprehensive and wide range of knowledge, and to have an interdisciplinary perspective. For its purpose, this course aimed to understand relations between science/technology and society, to understand STI for SDGs, and to consider relations between the learner and global society, or a goal of a future global career from a global or interdisciplinary perspective. In addition, this course aimed to improve the language (English) and communication skills through active learning in English. Thus, this course puts emphasis on considering, discussing, and sharing what is important for future global engineers.

4.2.2 The Program Contents

The main topics and learning objectives of the lecture course in Term 2 are shown in **Table 8**. The lecture course dealt with mainly the following topics: Foreigners view on Japanese culture, Relation between technology and society in disasters, SDGs as global common goals for future society, Society 5.0, International cooperation and global carrier. In Term 4, hours of the lecture on campus compressed and from the fourth class to the seventh class, a field study about the topics in the past three classes: Japanese culture, SDGs and Society 5.0 was adopted as shown in **Table 9**. In the field study, the students visited "Museum H", a Japanese traditional farmer's facility, "NGO A", a non-government organization specifically working on activities that contribute to SDGs, and "Company H", a global company whose main business is paper manufacturing with the concept of creating shared value for both contributing to SDGs and gaining benefits. In each class of both Term 2 and Term 4, group discussion was conducted to assume future situations/problems in society regarding the main topics in each class and discuss how to improve the situations/problems. Lastly, individual work was conducted for the students to think about what knowledge/abilities were required for global engineers, aiming to make a better understanding of the relationship between engineers and society.

Table 8. Main topics and learning objectives in each class (Term 2 in July 2018).

Class	Date	Main Topics	Learning Objectives
1	17 July 2018	Foreigners view on Japanese culture.	Understand diverse ideas about society in Japan.
2 and 3	19 and 20 July 2018	Relations between technology and society in disasters.	Understand relations between science/technology and society through Japanese disaster experiences.
4 and 5	21 July 2018	SDGs: global common goals for the future society.	Consider relations between the learner and SDGs from an interdisciplinary perspective by understanding STI for SDGs.
6 and 7	21 July 2018	Society 5.0: creation for future.	Consider future society or working environment by the development of science and technology.
8	21 July 2018	International cooperation and global carrier.	Consider the goal of a future career with a global perspective.

Table 9. Main topics and learning objectives in each class (Term 4 in January 2019).

Class	Date	Main Topics	Learning Objectives
1	16 January 2019	Foreigners view on Japanese culture, and relations between technology and society in disasters.	Understand diverse ideas about society in Japan. Understand relations between science/technology and society through Japanese disaster experiences.
2	16 January 2019	SDGs: global common goals for the future society.	Consider relations between the learner and SDGs from an interdisciplinary perspective by understanding STI for SDGs.
3	16 January 2019	Society 5.0: creation for future.	Consider future society or working environment by the development of science and technology.
4	17 January 2019	Fieldwork about topics in the past three lectures; Japanese culture, SDGs and Society 5.0.	Understand a part of Japanese traditional culture (the way of living for the farmers coexisting with the local environment, and its facilities) and think about the differences from Thai and Vietnamese culture, through the observation of "Museum H", a Japanese traditional farmer's facility.
5	17 January 2019	Fieldwork about topics in the past three lectures; Japanese culture, SDGs and Society 5.0.	Think about “What are the key points of technology transfer to Asia?" and "What value does technology transfer to Asia create in Japan and Asia from a global perspective or SDGs perspective?” through the introduction and the workshop on "NGO A"
6 and 7	17 January 2019	Fieldwork about topics in the past three lectures; Japanese culture, SDGs and Society 5.0.	Think about the value creation from the perspective of SDGs and Society 5.0, especially through the case of manufacturing by "Company H", a global company.
8	22 January 2019	Review the fieldwork from the viewpoint of SDGs in Society 5.0, and international cooperation as well as a global carrier.	Consider future society and/or working environment by the development of science and technology in terms of SDGs and Society 5.0. Consider the goal of a future career with a global perspective.

4.3 Methodology for Data Analysis

4.3.1 Target

This study's analyzed data included one case study of the lecture course which was carried out two times as an intensive course in Term 2 (in July 2018) and in Term 4 (in January 2019). The number of students participating in each class was 12 in Term 2 and nine in Term 4. The nationality of the students included Japanese, Laotian,

Vietnamese and Thai. The academic year of the students included the first year of the undergraduate level to the third year of the doctoral course (**Table 10**). Most of them came from the field of engineering (a total of 16 students); however, two students from food technology, two from science and one from finance were also included, and their majors were in many different fields. In the class, three teams consisted of cross-academic year, cross-disciplinary, and multinational students were formed in Term 2, and similarly, two teams were done in Term 4 to have GW activities. Also, all the 21 students attended a global PBL-type GW internship in the G-DORM that is a study abroad program conducted by NU in cooperation with four universities in the Mekong countries such as Cambodia, Laos, Thailand, and Vietnam [13]. The students of Term 2 had taken the lecture before participated in the G-DORM, in contrast, the students of Term 4 took the lecture during or after the G-DORM.

Table 10. Number of participants in lecture in AY2018.

Grade	Term 2				Term 4				Total
	Japanese	Laotian	Vietnam-ese	Subtotal	Japanese	Thai	Vietnam-ese	Subtotal	
B1	2	0	0	2	0	0	0	0	2
B3	0	1	0	1	1	1	0	2	3
B4	2	0	1	3	0	4	0	4	7
M1	5	0	1	6	0	1	0	1	7
D1	0	0	0	0	0	0	1	1	1
D3	0	0	0	0	0	1	0	1	1
Total	9	1	2	12	1	7	1	9	21

4.3.2 Data Collection and Analysis Methods

Firstly, in order to prove how ideas of the students on global engineers changed by the series of classes, individual work to answer the question of “What knowledge/ abilities are required for global engineers?” was conducted in both the first and the final class. This study conducted a comparative analysis of the first and the final answer. Secondly, in the assignment of the final report after the class, the students were asked to describe a free comment on the question “What roles should we engineer for the future society? And why do you think so?” This study attempted to

analyze frequent words in the answers by KH Coder which was developed as a free software used for quantitative content analysis or text mining in some researches [49]. Thirdly, to measure impacts to the students by the series of classes not only focusing on global engineering but also including other factors, the question of "What was the most significant change for you by taking the lecture?" was asked after the final class. The results were organized and analyzed for trends. This question was established based on the idea of the "Most Significant Change (MSC) Technique"[50], a method of project monitoring and evaluation that does not require indicators. Finally, the question of "Can the lecture be useful for your GW internship of G-DORM? If you recommend, when?" was asked to the students after the final class too, in order to analyze the usefulness of the classes.

4.4 Results and Discussion

4.4.1 Change of Ideas about Global Engineers

In the first class and the final class in each term, it was asked for the students to describe thinkable answers to the question of "What knowledge/abilities are required for global engineers?", then they were asked to choose the most important one among the above answers. The author categorized the selected answers into the following six categories: 1. Knowledge/skills in science and technology, 2. Social needs awareness, 3. Basic competencies for working persons, 4. Global competencies, 5. Positive attitude, 6. Others. The results are shown in **Fig. 12**. As a result, in the first class, five students answered some points related to "4. Global competencies" such as language and understanding differences of each culture; however, the number of students who answered it became zero in the final class. In summary, it was found that the series of classes made the students increase their awareness of the importance for global engineers to develop knowledge and skills on science and technology, to learn social needs, to gain basic competencies for working persons and to have a positive attitude.

The results of the calculation by nationality are shown in **Table 11**. "1. Knowledge/skills in science and technology" in the first class and the one in the final class were answered by Mekong students, whose number was two larger than the

number of Japanese students. In contrast, “2. Social needs awareness” was answered by Japanese students, whose number was four larger than the number of Mekong students in the final class. A distinguishing feature of “2. Social needs awareness” is that four Japanese students answered it however nobody answered from Mekong students in the final class. This implies the importance of grasping social needs was more impressive to Japanese students.

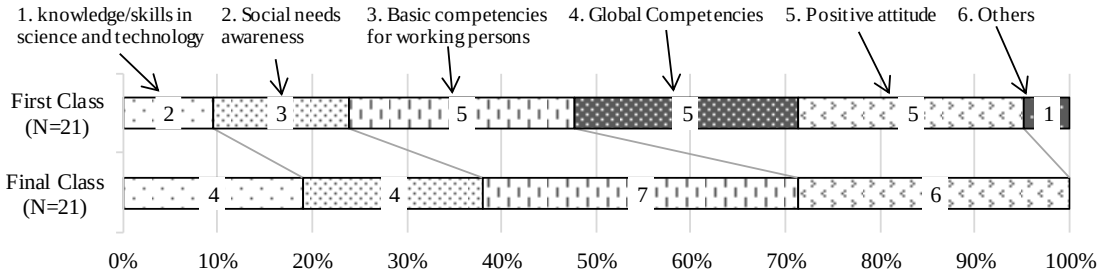


Fig. 12. Number of respondents to the most important thing for global engineers.

Table 11. Number of respondents to the most important thing for global engineers (by nationality).

Category	First Class			Final Class		
	Mekong	Japanese	Subtotal	Mekong	Japanese	Subtotal
1. Knowledge/skills on science and technology	2	0	2	3	1	4
2. Social needs awareness	1	2	3	0	4	4
3. Basic competencies for working persons	3	2	5	5	2	7
4. Global competencies	2	3	5	0	0	0
5. Positive attitude	3	2	5	3	3	6
6. Others	0	1	1	0	0	0
Total	11	10	21	11	10	21

Moreover, **Fig. 13** shows the number of respondents who changed or NOT changed his/her idea about the most important thing for global engineers, compared to the first class and the last class. It is interesting that about half of the Mekong students did not change their opinions, however, all of the Japanese students changed their opinions. One of the reasons can be thought that many subjects of the classes were related to science and technology in Japan.

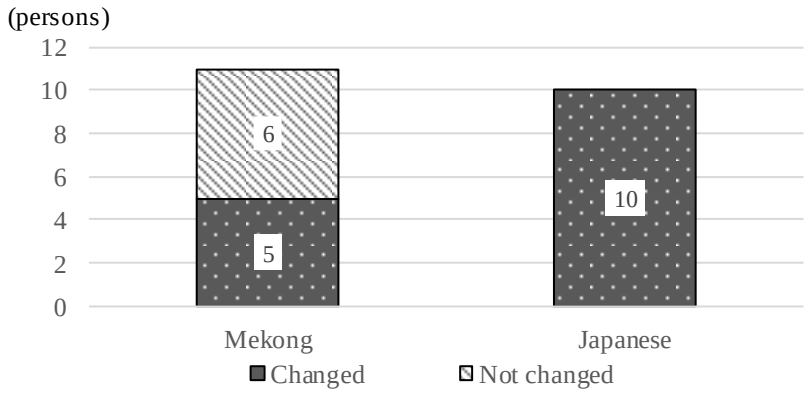


Fig. 13. Number of respondents who changed or not changed idea about the most important thing for global engineers.

4.4.2 Ideas on Roles of Global Engineers for Future Society

Frequent words by part of speech which came from the result of text mining to free comments of the 21 students answering the question of "What roles should global engineers play for future society? And why do you think so?" was shown in **Table 12**. Focusing on verb frequent words, "be", "think", and "have" follow by term generally causing make things to be assumed, such as "work", "create", "develop", "make", and "improve". In addition, while focusing on nouns, words reminiscent of engineering such as "technology" and "product", as well as words reminiscent of society such as "people", "country", "SDGs", "environment", and "life" have appeared frequently, except words which include in the sentence of the question. **Table 13** shows the frequency rate of words in the answer about the roles of global engineers for future society by the term, academic year, and nationality respectively. In particular, students of Term 2 frequently used words such as "think" and "I", however, the ones of Term 4 hardly had such words. It is inferred that the students of Term 4 tended to show a clearer answer to this question than the ones of Term 2. Differences in it between Term 2 and Term 4 were more appeared than the one between nationalities. On the other hand, "technology" and "skill" in Term 4 marked a high score as a frequency rate of words. Thus, students in Term 4 could be better recognized about the importance of technology and/or skill for future society than the one in Term 2, since

they already experienced practical engineering work at a company through their internship ongoing or completed.

Table 12. Frequent words in the answer about roles of global engineers for future society (by part of speech).

Noun		Subject		Adjective		Adverb		Verb		Relative	
engineer	60	I	35	global	35	not	17	be	87	that	10
society	40	they	23	new	19	also	10	think	27	which	10
people	18	we	17	future	14	so	8	have	23	who	7
technology	18	it	6	many	10	only	7	work	17	when	4
world	13			important	8	therefore	5	create	13	how	2
problem	11			other	6	now	4	develop	11	what	2
role	11			such	6	just	3	change	8	why	2
goal	10			creative	5	more	3	make	8		
product	10			sustainable	5			improve	7		
country	9			technical	4			play	7		
engineering	9										
SDGs	8										
environment	8										
life	8										

Table 13. Frequency rate of words in the answer about roles of global engineers for future society.

By Term				By Student Level				By Nationality			
Term 2		Term 4		Undergraduate		Graduate		Mekong		Japanese	
think	.800	technology	.667	global	.556	engineer	.500	technology	.692	think	.667
I	.786	skill	.400	think	.500	they	.500	be	.550	I	.643
engineer	.667	who	.364	people	.467	have	.467	society	.444	world	.500
be	.600	new	.357	technology	.438	be	.450	who	.417	not	.500
have	.563	energy	.333	work	.438	future	.429	new	.400	engineer	.474
global	.556	leadership	.333	world	.438	not	.417	people	.400	global	.444
not	.539	role	.308	work	.417	society	.412	apply	.364	have	.438
future	.533	apply	.300	new	.375	country	.400	that	.357	also	.417
work	.533	knowledge	.273	we	.375	environment	.400	knowledge	.333	future	.400
world	.533	need	.273	idea	.333	need	.400	skill	.333	work	.400

4.4.3 The Most Significant Change by Taking the Lecture

Results of the answer to the question of "What was the most significant change for you by taking the lecture?" are shown in **Table 14**. In the table, the category that is

designated by the author from each answer is also indicated. Six students indicated regarding SDGs, three students did regarding global engineers, two students did regarding Society 5.0, the other two students did regarding contribution to society, similarly, the other two did regarding wider perspectives, and the other two did regarding new information. This result implicates that most of the students understood and emphasized the importance of the relationship between engineering and society.

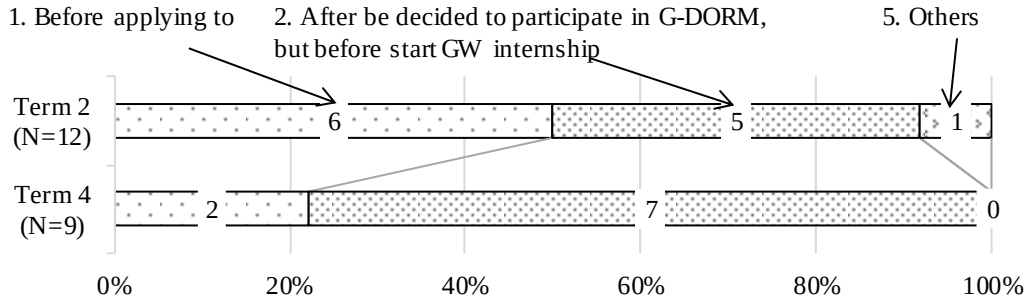
Table 14. The most significant change for student his/herself by taking the lecture.

Category	Answer of Most Significant Change for Student His/Herself
SDGs	Became to tell many people how important to think about SDGs.
	Was able to know SDGs.
	Improved knowledge to create a sustainable society based on the SDGs criteria.
	Knew new management plans such as SDGs.
	Gained new knowledge about SDGs.
	Understood how to find and get business chances based on SDGs point of view.
Global engineers	Understood a model of global engineers I should orient and our governments need.
	Could find clear duty for global engineers.
	Changed the view of society where I made products as an engineer in the future.
Society 5.0	Understood how society 5.0 would change our life and the problem that we have to deal with.
	Gained more knowledge about Japanese policies (Society 5.0).
Contribution to society	Changed a target to do from what I am interested in to what I can help for a person in trouble.
	Had awareness of social contribution.
Wider perspectives	Widened my views to think.
	Changed my mind to be a person who has a wider perspective.
New information	Was having various knowledge more important than English communication skills.
	Gained new information and teamwork
Social issues	Developed my understanding of social issues and future trends, which will benefit me in the future.
Others	Satisfied about active lecture style (active learning)
	Learned the difficulties for determination.

4.4.4 Relationship with the G-DORM PBL-type Internship

The result of the answer to the question of "What timing is the best to take the lecture?" is shown in **Fig. 14**. Consequently, all of the students in both Term 2 and Term 4 except for one student chose options that indicated the timing of taking the

lecture before the G-DORM PBL-type internship. In addition, the content of “5. Others” which was answered by the one student was “Any timing would be acceptable”. Thus, it is proved that students thought the lecture on SDGs and Society 5.0 with active learning was useful for getting tips in the G-DORM PBL-type internship, where students were required to identify and solve actual problems in a hosting company.



Notes: Nobody selected option "3. After the end of GW internship" nor "4. I do not want to recommend the lecture to classmate"

Fig. 14. The best timing to take the lecture.

4.5 Conclusions

This chapter showed achievements of active learning for 21 multinational students from Mekong countries and Japan to think about global engineers through lecture and GW on SDGs and Society 5.0, which took place in AY2018 at NU. It was found that active learning made the students increase their awareness of the importance for global engineers to develop knowledge and skills in science and technology, to learn social needs, to gain basic competencies for working persons. and to have a positive attitude. In addition, it was the most significant change for students to gain SDGs, global engineers, Society 5.0, or other new information, as well as to have social contribution and wider perspectives. This result implicates that most of the students understood and emphasized the importance of the relationship between engineering and society. Furthermore, the students rated this active learning as useful as a pre-study for a global PBL-type internship, which is one of the featuring internships in the G-DORM project.

Though this course has only one-year experience as a pilot and the number of students who completed this course was only 21, the results of the discussion in this chapter implied enough that active learning on SDGs and Society 5.0 had high potential and was useful to foster engineering students who were able to find challenges and/or needs for sustainable development. It is needed to compile more practices and effective verifications for making better ways of active learning in the course. Also, it is one of the challenges for the course to be integrated into the curricula at the institutional level so that students can consider the relationship between their own specialty and/or their hoped career.

CHAPTER 5
CONCLUSIONS

5.1.1 Executive Summary and Implications

This study aimed to argue the effectiveness of—and challenges in—multi-cultural and multi-disciplinary team-based PBL dealt with real-world problems in engineering education through the case study of the G-DORM project. In particular, this study analyzed the developed three-type pedagogical approaches: 1) internships in the industry; 2) short-term industrial experiential learning; 3) lecture courses. Through these analyses, this study attempted to contribute to learning the practical effectiveness of a PBL dealt with real-world engineering problem-solving which have been predicted to enhance global engineers' competencies through it has less discussion. For the sake, this study argued the followings through the case studies of each the three-type pedagogical approaches in the practice of AY2018 and AY2019 in the G-DORM project: enhancing students' competencies for global engineers; enhance students' motivation for further learning towards engineering careers; creating the synergy of each pedagogical approach.

Chapter 2 presented the result of the case study on the analysis of internships in the industry. A key finding is that the G-DORM approach-based internships could positively affect students' competence with regard to global engineering, especially through the designing of stepping-up programs aimed at developing competence. Also, the study results suggested the optimization of internship periods, pre-studies, intervention by moderators during internships for enhancing learners' capacity for solving revitalization issues using an integrated standpoint. The chapter also suggested the improvements in post-studies for promoting the metacognition of learners' interests in the industry with the sake of influencing the future development of their competence and career.

Chapter 3 presented the result of the case study on the analysis of short-term industrial experiential learning. The result suggested that the short-term industrial experiential learning in G-DORM increased students' satisfaction and interests in the

regional industry as well as developed the motivation and the actual action of students in a step-up tendency. A consequence of this is the high possibility that industrial experiential learning is a beneficial method of engineering education that can be the entry point to promote education for better understanding and realization of how to connect with society such as industry and overseas.

Chapter 4 presented the result of the case study on the analysis of lecture course where students proposed Sci-tech challenges for SDGs by team-based learning. The result of the lecture course implicates that most of the students understood and emphasized the importance of the relationship between engineering and society. Furthermore, the result highlighted that the students rated this team-based lecture as useful as a pre-study for the G-DORM PBL-type internships in the industry.

Taken together, the evidence from the case studies in Chapters 2, 3, and 4 implicates the combination of the three pedagogical approaches creates the synergy of learning effectiveness. The study proved that stepping-up learning from the short-term industrial experiential learning to the internships in the industry is useful and recommended for developing competence. The lecture course can use for a pre-study of the internships in the industry focusing on the importance of the relationship between engineering and society, which can enhance the perspective for solving revitalization issues using an integrated standpoint.

In conclusion, the study indicates that multi-cultural and multi-disciplinary project-based, internship-based learning effects to enhance students' global engineering competence. In addition, the internship in combination with the pedagogical methodology of the short-term industrial experiential learning and the lecture course helps to supplement the disadvantage of the internship.

5.1.2 Limitations and Recommendations for Further Studies

This study has some limitations. Since this study still dealt with only 2-year practices in the G-DORM internships and only one-year experience in the G-DORM short-term industrial experiential learning and the G-DORM lecture as a pilot, the number of students may not be sufficient for the generalization. It is needed to

compile more practices and effective verifications for making better ways of the G-DORM pedagogical approaches. In particular, this study could not analyze the correlation between students' self-efficacy and the combination of the theme of the PBL and students' grades or specialties in the cases of the internship and short-term experiential learning. If this is revealed, we can make a more effective team-based PBL-type internship program with the G-DORM pedagogical approaches. Despite the small sample size, the result of this study could be the basis of proving the effectiveness of multicultural and multi-interdisciplinary team-based PBL dealt with a real-world problem in engineering education.

Another important issue for further research is to conduct a follow-up survey for students, where they would be required to identify how the G-DORM pedagogical approaches, especially the internship, impacts their future studies and career. In addition, the G-DORM internship, which proposes solutions for resolving real-world problems through education, could lead to not only the fostering of global Sci-tech leaders but also the enhancing of industry-university collaborations and support for industries in lower Mekong countries, especially with regard to resolving their issues. These issues are also reserved for future work in this research direction.

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[2] **Y. Ueda**, N. Tsuboi, T. Suzuki, I. Kourakata, and E. Wakabayashi, “Group Work Internship as Global Project-based Learning towards Further Learning Motivation: G-DORM Short-term Program 2019,” JSEE Annual Conference International Session Proceedings, vol. 2020, p. 6, 2020.

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APPENDIX

Questions of the questionnaires used for the analysis in Chapter 2 and Chapter 3.

(1) The pre- and post-questionnaire to students for collecting the data on ***generic skills*** and ***global competencies for engineers***.

ID	Indicators	Questions
1.1	Initiative	I take initiative in finding tasks and solving problems.
1.2	Ability to influence	I am able to cooperate with my friends and colleagues to solve problems.
1.3	Execution skill	I set up a goal by myself and make effort to achieve it.
1.4	Ability to detect issues	I am able to analyze current situation to identify problems and share them.
1.5	Planning skill	I am able to find my own solution to a problem and execute it as planned.
1.6	Creativity	I am an innovative person who can think creatively and come up with unique ideas.
1.7	Ability to deliver messages	I am able to express my opinion precisely to make myself understood.
1.8	Ability to listen closely and carefully	I am a good facilitator to make people talk comfortably and to encourage active and appropriate comments.
1.9	Flexibility	I am a flexible person who considers others' opinions and position.
1.10	Ability to grasp situations	When working in groups, I can figure out surrounding environments properly.
1.11	Ability to apply rules and regulations	I am able to follow the rules or procedures and express myself accordingly.
1.12	Ability to control stress	I move forward even if I find it challenging, because it will increase my capability.
1.13	Ability to collaborate with foreigners	I am able to conduct my leadership in different culture or among people with different value sets.
1.14	Challenging spirits	I am not afraid of taking a risk when it is worth trying.
1.15	Ability to communicate with foreigners	I somehow try to convey what I want to say even though my foreign language skill is not good enough yet.
1.16	Intercultural understanding	I am able to understand and accommodate people who have different religion and cultural background.
1.17	Intercultural exchange experiences	I have a cross-cultural experience both in my home country and abroad.
1.18	Study motivation for my major	I am highly motivated to study my specialty.
1.19	Study motivation for learning foreign languages	I am highly motivated to study foreign language.
1.20	Knowledge regarding Mekong country/Japan	I have fundamental knowledge of the society, habits and culture in the country where you study abroad.
1.21	Knowledge or interests regarding Mekong/Japanese society	I have knowledge or interest of politics, social issues and international relations.
1.22	Awareness of the gender equality	I am aware of the importance of the gender equality in society.
1.23	Future study and carrier design	I have a clear vision of my future study or job career path.

(2) The post-questionnaire to students for collecting the data on ***capacity for solving revitalization issues using an integrated standpoint*** and ***interests in the industry***.

ID	Items	Questions
2.1	Problem-solving with interdisciplinary approach	I have increased ability to find out a solution by integrating necessary knowledge and technology for concrete problem-solving.
2.2	Awareness regarding global technical or economic issues	I have increased ability to find out technical or economic problems on industries in Niigata for extending its business in the Mekong.
3.1	Interests in the company/industry	I have increased interests about the company visited and/or its related industry.
3.2	Demand for obtaining a job with the company	I want to consider positively to get a job with the company.
3.3	Demand for participating in more internships in the company	I want to participate in internships at the company more.
3.4	Demand for maintaining a relationship with the company	I want to consider having connection with the company if I work for its related industry in future.
3.5	Motivation to buy products/services from the company	I want to buy products and/or services provided by the company if I have a chance.
3.6	Motivation to disseminate the values of the company	I want to inform values of the company to someone I know.

(3) The post-questionnaire to hosting companies for the data collection.

ID	Items	Questions
1.1	Initiative	Could s/he actively work towards things?
1.2	Ability to influence	Could s/he motivate others in order to work towards the objectives?
1.3	Execution skill	Could s/he set own targets of work and carry out them steadily?
1.4	Ability to detect issues	Could s/he identify objectives and issues based on current situation in his/her work?
1.5	Planning skill	Could s/he clarify processes and making preparations with a view to resolving issues?
1.6	Creativity	Could s/he devise new solutions for issues, without sticking to conventional ideas?
-	Ability to work in a team	Could s/he collaborate with others to achieve goals?
2.1	Problem-solving with interdisciplinary approach	Could s/he consider solution to a problem, with interdisciplinary approach?
2.2	Awareness regarding global technical or economic issues	Could s/he identify possibilities and/or challenges on overseas extension of the corporation?
2.3	Knowledge regarding technology of the company	Could s/he understand theories and/or technology of the corporation?
2.4	Knowledge regarding advantages in the company/related industry	Could s/he understand strengths and weaknesses of the corporation and/or regional industries?