

# Effects of Bilateral Problem-based Learning Program for Engineering Students:

## Case of a Joint Course with Japan and Thailand

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**Abstract**— The purpose of this paper is to assess the learning outcomes of a problem-based learning (PBL) program within multi-cultural setting for students majoring in engineering. To meet the pressing needs of global issues such as population change, energy, and environment, the tasks required for engineers have expanded in recent decades to include working in multicultural environments. There, along with technical skills and knowledge in their fields of expertise, engineers are required to be equipped with skills and minds able to work in these fields. As such, higher educational institutions have conducted educational reform to develop active learning along with inter-country university programs. Tokyo Institute of Technology in Japan and Chulalongkorn University in Thailand developed a joint PBL program titled “Global Awareness for Technology Implementation in the Solving of Social Issues”. The uniqueness of this PBL program is that it combined the virtual on-line group work and face-to-face meeting. This paper summarizes the process of curriculum development, pedagogy utilized in the course, as well as research findings and its reasons. Through this process the paper aims to discuss challenges and opportunities for future prospects of global engineering education utilizing digital devices to promote inter-cultural PBL.

**Keywords**—*Problem-based Learning; Multi-cultural Environment, Virtual Setting, Engineering Education, Global Issues*

### I. INTRODUCTION

To meet the pressing needs of global issues such as population change, energy, and environment, engineers must possess not only technical knowledge and expertise but also to work in multicultural environments. That is to say, as many of the causes of global issues have occurred in cross-national situations, the solution of which require cooperation among different countries. Thus it is highly likely that engineers will be working with people of different background, in terms of their field of expertise, thoughts, perspectives, approaches, as well as nationalities. Also, diversity should be highly respected with the expectation that it is likely to bring new thoughts and ideas incorporating differences to improve the current socioeconomic systems of many kinds. In order to respect diversity, it is important that one will be able to work in multicultural team and communicate effectively with different types of people which should be supported by their

critical thinking. To develop critical thinking, ideas and thoughts and suggestions should be based on decent background, support, and evidences. By knowing, respecting and accepting the differences and diversity, one will be able to successfully localize, adapt and customize technology. Allan and Chisholm (2008) stretch the point on needs of developing competencies for global contexts on engineers such as embracement of ethics, presentation of empathy, critical thinking, development of culturally appropriate relationship, utilization of information and communication technology (ICT), ability to work within inter and transdisciplinary systems, interacting interpersonally under culturally/ethnically/linguistically different situations [1]. As such, need of curriculum reform in engineering education was emphasized. Wilcox and Wilcox point out the importance of integrating sciences in the context of realistic problem-solving, which will eventually leads students to another important level of career options[2].

In meeting the demand for engineers to be equipped with skills necessary to meet socioeconomic needs in real world, higher educational institutions have conducted educational reform to develop active learning along with inter-country university programs. Problem-Based Learning (PBL) is considered to be effective pedagogy [3, 4, 5], as PBL involves small groups of students working in permanent groups to learn the course content within the framework of a realistic problem [6, 7]. Further, Montgomery (2008) mentioned that in this past decade, students are likely to prepare to work in international contexts as part of their learning experience [8].

It is expected that through PBL, students will be brought up with critical thinking and analysis, effective communications skills, development of lifelong learning skills [9, 10, 11, 12, 13], which are all discussed as essential skills for engineers for the new era. PBL in a multi-cultural environment has been considered beneficial as it would motivate students to further increase their levels of interests in topics, bring cognitive engagement, initiate conceptual change, develop respect as well as acceptance, and tolerance to others [14, 15, 16, 17]. In one university in the United States, where many of the American students are not interested in working abroad, PBL involving international students seemed to be effective in increasing the motivation for local students to

understand global engineering problems and seek for sustainable solution [18]. On the other hand, it is reported that at university that has conducted PBL in multicultural teams in one place had some issues on language communication, unbalanced workloads to local students and so forth [19]. As a breakthrough in conducting effective multicultural PBL, practitioners raised the needs of digital interventions such as virtual laboratory [20], and collaborative multidisciplinary technology-based efforts to benefit faculty, administrators and students [21]. While the demands of both multicultural PBL and utilization of ICT in conducting inter-university activities have been recognized, there are only few researches on practices, pedagogies, and effectiveness of PBL in multicultural student groups, as well as multicultural PBL using ICT. Meanwhile, aforementioned situation related to needs of engineering education reform implies that universities are in the good timing to develop active learning style coursework in international environment to deal with real world problems.

Tokyo Institute of Technology (TIT) in Japan and Chulalongkorn University (CU) in Thailand, as leading universities for engineering education and research in Asia, one of their missions is to educate students to take leadership in social innovation and structural change. Graduates from TIT and CU are expected to adopt new approaches in socioeconomic issues through their field of expertise, added to wide views and skills necessary to work in international environment. As such, TIT and CU jointly developed a PBL program titled "Global Awareness for Technology Implementation in the Solving of Social Issues". The uniqueness of this TIT-CU bilateral PBL program is that it combined the remote sessions, face-to-face meeting, and site visits as an effective practice and pedagogy to develop students' skills to work in multicultural setting.

The purpose of this paper is to assess the learning outcomes and the effects of bilateral PBL program for engineering students in Japan and Thailand. It is aimed to identify the gained skills mentioned in previous literatures through this bilateral PBL and its methods. Also, this paper will seek for other effects on this newly developed multicultural PBL program, that previous multicultural PBL have not discussed. In so doing, this paper summarizes (1) the process of curriculum development, (2) pedagogy utilized in the course, and (3) research findings and its reasons. Through this process the paper aims to discuss challenges and opportunities for future prospects of global engineering education utilizing digital devices to promote inter-cultural PBL.

## II. CURRICULUM DEVELOPMENT

To start TIT-CU bilateral PBL program, initial face to face meeting was conducted in February 2015 at TIT campus in Japan, inviting relevant personnel from CU. During the meeting, it was agreed to set following course objectives for engineering students: (1) to build global awareness for successful technology implementation, (2) to understand different cultures and respect differences, (3) to be able to work in multicultural team and communicate effectively, (4) to think critically and (5) to be able to localize/customize the

technology for different cultures. The course was developed in a way to share the commonalities and differences on the selected three themes that are common issues in Japan and Thailand to find the proposed solutions incorporating each countries ideas/practices.

After brainstorming of the ideas, the two universities selected three themes, namely, disaster management, waste management, and transportation. As selected themes are common problems both in Japan and Thailand, it was considered that students could learn from each other by sharing their countries' own experiences. There were a few issues to consider while developing this PBL course. The issues include (1) calendar and credit, (2) student selection, (3) evaluation of performances, and (4) course requirement, each of which will be described in following sections.

### A. Calendar and Credit

It was necessary to carefully consider number of credits for the program especially since Japan and Thailand to follow different academic systems. In case of TIT, there have been other four similar PBL courses already run for two years before this TIT-CU bilateral PBL program, which are all run for 1 credit course. Also as this course was run as part of the "Global Scientists and Engineers Course", which is a series of educational program to strengthen the international capacity of undergraduate students, it was decided that this new PBL course should be organized under the same scheme, thus kept as 1 credit course.

Whereas normal course at CU is 3 credits for a 15-week semester, class meets once a week, 3-hours per session. Therefore, possible options are whether to offer a 1.5 credit or 3 credit course. Based on TIT and CU's calendar, both universities found that the best mutual period of the course should be between first week of October until the end of November. This schedule fits the second half of CU's first semester that runs from second week of August to first half of December with midterm at the end of September and final during the first 2 weeks in December. For TIT, it is fall semester that runs from the beginning of October to the mid of February with a break during Christmas to New Year, and the final exam in February. As a result, TIT and CU agreed to conduct mutual classes between the first week of October to the end of November which qualifies as a 1.5 credit course for CU. However, because the approach of PBL course is relatively new to CU especially in the Engineering school, CU decided to prepare students before the mutual class by offering this course as a full 3-credit course, running from August to December.

### B. Student Selection

At TIT, pre-application for the students was conducted based on announcement on website and e-mail news, along with some recommendations from professors involved in this TIT-CU bilateral PBL program. During the pre-selection, students were asked to submit information about English level, English communication capacity, and motivation for the group work with Thai students. There were total of 8 students registered for course. Symbolized by the rich body of the international students at TIT, 4 students were international students, one from Republic of Korea, one from Indonesia,

and two from China. The rest of 4 students were Japanese. They were from variety of engineering department, namely international development, mechanical engineering, civil engineering, and biological engineering. TIT assigned one teaching assistant (TA) from Thailand, who received her bachelor and master degree from CU.

Aside from the international programs, all classes at CU are taught in Thai. Therefore, it is quite rare to offer courses in English for the Thai programs. First impressions from the students were mixed. Some were excited, and others were reserved. To make sure that students are capable of English communication and to draw students who are interested in multidisciplinary course such as this one, an electronic poster was circulated on the school's social network. It asked students to write a 1-page essay in English to express their interest in the course and on the themes. Students were selected based on their interest and their English communication skills alone. CU shortlisted 8 students. They came from various departments in Engineering, such as chemical engineering and computer engineering.

### C. Evaluation of performances

Assessment was decided to conduct on two parts, namely individual assessment and group assessment. For group assessment, all group members would be evaluated with equal points. More weight was put on individual performances than group performances. Specifically, 70% of the grade was based on individual performance where as 30% of the grade was based on group performance. Individual assessments consist of group work performance, report chapters in charge, and personal essay. Group assessment includes overall report, group presentation and group discussion.

### D. Course Requirement

TABLE I. REPORT STRUCTURE

Chapter	Content		Detail s of content	Volume	No. of members to be assigned
1. Introduction	General description about the research topic		<ul style="list-style-type: none"><li>● Issues, social impacts, projections,</li><li>● Objectives of the report</li><li>● Overall structure of the report</li></ul>	200 words +	1
	Research Method			200 words+	
2. Research Result	Case Study 1 Thailand	Country's basic data	population, area, political system, etc.	400 words+	1
		Current situation of the topic	Current situation of the topic, socioeconomic background, current policy, evaluation	800-1000 words +	2
	Case Study 2 Japan	Country's basic data	population, area, political system, etc.	400 words+	1
		Current situation of the topic	Current situation of the topic, socioeconomic background, current policy, evaluation	800-1000 words +	2
3. Research Finding	Commonality			400-500 words+	2
	Differences			400-500 words +	
4. Proposal	Proposal for the topic	For Thailand	Technology, policy, any other efforts	800-1000 words +	2
			Practicality, feasibility	400-500 words +	
	Proposal for the topic	For Japan	Technology, policy, any other efforts	800-1000 words +	2
			Practicality, feasibility	400-500 words +	
5. Discussion	Relationship between Thailand and Japan (in general/broader term)			400-500 words +	2
	Possibility of bilateral cooperation for the improvement/enhancement of the topic			400-500 words +	
Personal essay about the topic				400-500 words +	(all)

Table I shows the report structure. Each group was requested to submit the one group report, incorporating the

contents above. The group work was conducted in a way to share the current situation of the issues for both countries, and then make comparison to find commonalities and differences. Students were then requested to make proposal, incorporating other countries experiences, cases, or good practices. Finally based on their proposal, further possible cooperation between two countries were to be discussed.

## III. PEDAGOGY

As indicated above, CU started the course individually before the joint session. At CU, the first half of the semester was dedicated to lectures and field trips in Bangkok and its vicinity in the areas of the 3 themes. The first lecture was on global awareness in general. In the subsequent weeks, students were asked to read articles related to a theme. They discussed the papers before or during each visit. After the visits, they identify local problems and propose possible solutions. A new and exciting activity was a group work that demanded students to conduct a research in waste management by exploring existing situation in the school. Students were able to submit the paper to an international conference, and the paper was accepted to present the work during the semester.

The latter half of the course, TIT and CU students met for one and a half hours weekly. The first mutual class started with the introduction of students and instructors to allow students to team up. The group work was conducted to pair the members with 2-3 students with the facilitation of two instructors from each university. Polycom was used on both sides to televise the lectures. Students used Google Hangouts to communicate among team members, and a central Google drive to share files. In order to strengthen the connection, Facebook Group page was created to share any information activities related to the program. During the second class, TIT invited subject matter experts to give three lectures. CU conducted the lectures on the three themes by three professors in the same format the following week. In addition, students met on their own time to discuss the topics and give presentation on the progress weekly during class. The three subsequent weeks were dedicated to progress reports from students along with comments and suggestions from instructors and TAs. The plenary session was dedicated to (1) proposal presentation, (2) sharing the current situations of the selected topics in Japan and Thailand, and (3) findings for commonalities and differences between two countries, and (4) proposals to improve the selected topics. During each session, first half part was dedicated to group discussion among three groups, followed by presentations and discussion in the whole class. Finally, the dispatch from CU to Japan was organized during Dec 17-24, 2015.

## IV. MEASUREMENT OF LEARNING OUTCOMES

### A. Methods

In order to assess the learning outcomes of the students for the TIT-CU bilateral PBL program, 1) content analysis on group work outcomes namely the presentation, final report, and personal essays, 2) pre and post survey using Likert scale, and 3) participant observation were conducted. Following the objectives of the course, five assessment indicators namely (1)

Global awareness (GA); (2) Multicultural understanding (MU); (3) Multicultural teamwork (MT); (4) Critical thinking (CT); and (5) Technology localization (TL) were set.

1) Content analysis on final presentation and report was utilized to assess indicators (1) Global awareness; (2) Multicultural understanding and (5) Technology localization. Specifically, level of integration on knowledge sharing was determined through the contents of presentation and final report for three groups focusing on targeted topic and proposal. Personal essays were utilized to assess the individual level of achievement for all five indicators. Sentences to symbolize each indicator were carefully determined and noted. Some sample sentences are listed in the result (Table V). For 2) Pre and post survey using Likert scale, self-evaluation ranging from very low (score 1), low (score 2), average (score 3), high (score 4), and very high (score 5) was utilized to measure the motivational change before and after the course to assess all five indicators. Table II summarizes the construct of the survey and analytical framework for indicators. Based on the questionnaire survey result, average score for each answer as well as rate of change before and after the course were calculated separately for students from TIT and CU to make comparison. 3) Participant observation was utilized to assess (1) Global awareness, and (3) Multicultural teamwork.

TABLE II. PRE AND POST SURVEY INDICATORS

Indicator category	Questions	Item in the graph
1) GA	1. Level of interest on problems among different societies	1. Problems interest
	2. Confidence of becoming a Global Human Resource	2. GHR confidence
	3. Impact on your future plans (Does this class has any effect on your future plan or to encourage you to work in multinational environment?)	3. Future plan
	4. Interest on advanced countries	4. Advanced countries
	5. Interest on developing countries	5. Developing countries
	6. Interest on working in developing countries	6. Work at developing countries
	7. Interest on contributing for the development of developing countries	7. Contribution to developing countries
	8. Interest on going abroad for further studies	8. Study abroad
	9. Overall motivation to visit abroad	9. Visit abroad
	10. Overall interest about the Foreign Study Program	10. Foreign study program
	11. Interest on going abroad for job-related activities	11. Going abroad for job
2) MU	12. Understanding of cultural differences	12. Cultural differences
3) MT	13. Importance of respecting differences	13. Respecting differences
	14. Ability to work in multicultural team	14. Multicultural team
	15. Communication skills in general	15. Communication skill
4) CT	16. Presentation capability	16. Presentation capacity
	17. Ability to communicate in English	17. English communication
	18. Ability to think critically	18. Critical thinking
5) TL	19. Ability to identify problems of the society	19. Identify social problems
	20. Ability to find solutions for the identified social issues	20. Find solution
	21. Ability to develop ideas to localize/customize technology for different cultures	21. Technology localization
	22. Awareness on successful technology implementation on global scale	22. Technology implementation

## B. Results

### 1) Content Analysis

Among three groups, Waste management team selected different focus, thus ended up on different proposal on both side. While they could not incorporate each other's practice due to the gap on topic focus, there have learned the good practice and current situations on other country. Transportation team selected the same focused topic, and shared the good practice between two countries. They

concluded with separate proposals with individual ideas from own country. Still they shared the good practice and situations behind the traffic jam in each country. Disaster Management team selected the same focused topic, and successfully incorporated each country's practice to own country's proposal. They have shared the commonalities and differences and obtained ideas to suit its own country's situation. From the analysis above, it is fair to state that (1) Global awareness and (2) Multicultural understanding were successfully increased for all groups, while one team moved further to increase on awareness on (5) Technology localization (Table III).

TABLE III. OUTCOME OF FINAL PRESENTATION AND REPORT

Theme	Focused Topic	Proposal	Level of incorporation
Waste Management	TIT: Plastic waste reduction CU: Waste Separation	TIT: related to 3Rs (Reduce, Reuse, Recycle) CU: Quiz to promote awareness	Learn the ways on good practice on each other, situation of different country
Transportation	Reduction of number of cars on roads	TIT: Car sharing CU: Bus safety with voting on drivers	Learn the ways on good practice on each other, situation of different country
Disaster Management	Flood mitigation	TIT: Building temporary underground reservoir (idea from small reservoir in Thailand) CU: Connecting small reservoirs and giant tunnel. (idea from underground canal in Japan)	Successful in incorporating the counterpart country's practice to one's country's solution.

TABLE IV. LEVEL OF PERSONAL CHANGE

	Global Awareness	Multicultural Understanding	Multicultural Teamwork	Critical Thinking	Technology Localization
TIT 1 (WM)			✓		
TIT 2 (WM)				✓	
TIT 3 (WM)				✓	
TIT 4 (TP)	✓			✓	
TIT 5 (TP)		✓	✓	✓	
TIT 6 (TP)	✓	✓	✓	✓	✓
TIT 7 (DM)	✓	✓	✓	✓	✓
TIT 8 (DM)	✓	✓		✓	✓
CU1 (WM)	✓		✓	✓	
CU 2 (WM)	✓		✓	✓	
CU 3 (WM)	✓		✓	✓	
CU 4 (TP)	✓	✓	✓	✓	
CU 5 (TP)		✓	✓	✓	
CU 6 (DM)	✓			✓	✓
CU 7 (DM)				✓	✓
CU 8 (DM)	✓	✓		✓	✓

By picking up sentences to show the self-development related to five indicators in the personal essays for individual students, level of personal change was determined (Table IV). For (1) Global awareness, Chula students had higher awareness than TIT students. In total, (2) Multicultural understanding, (3) Multicultural teamwork, and (5) Technology localization, there are not much of a differences between students from two universities, for (4) Critical thinking, almost all students developed some skills. From the content analysis, findings can be summarized as follows. First, many student have developed skills related to critical thinking.

Second, more than half of students have established skills related to global awareness and multicultural teamwork. Few students have developed skills related to multicultural understanding and technological localization.

TABLE V. SAMPLE SENTENCES TO SYMBOLIZE THE SELF-DEVELOPMENT OF INDICATORS

<b>Global awareness</b>	<p>"Attending the course was my great opportunity to get to know with foreigner and learn their culture and our differences."</p> <p>"After taking this class I decided to take my time to prepare study abroad and think that I might learn something new about South-East Asian countries"</p> <p>"This class gave me an opportunity to expose to many fields. Therefore this course broadened my perspective and my understanding in the different cultures."</p>
<b>Multicultural understanding</b>	<p>"This course taught me about how other country's view about Japan and also how I should view another country, in this case Thailand."</p> <p>"The most important thing is to learn from the past and learn from our friends."</p> <p>"Situations of other people or other country are the things we also have to learn."</p>
<b>Multicultural teamwork</b>	<p>"I find difficult to communicate with our Thai friends by videophone, but it is still a good experience for me."</p> <p>"I need collaboration skill since I did not do the whole work alone, many pieces were gather together."</p> <p>"The communication duty gave me a change to know my Thai friends more deeply and also make friends with Japanese"</p>
<b>Critical thinking</b>	<p>"The process of consideration was quite interesting and meaningful."</p> <p>"Information acquirement and synthesizing skill to extract useful information from internet and build up new knowledge combination were also needed."</p> <p>"The skills and knowledge required for my contribution were observation skills, analytical skills, and knowledge of different waste sorting systems"</p>
<b>Technology localization</b>	<p>"the same way of solution can solve the same problem in the other countries as well which might not work. That is why we have to study this subject"</p> <p>"I must know the information, culture and belief from both Japan side and Thai side to see what have in common or which point to think or take action in different ways."</p>

## 2) Pre and Post Survey

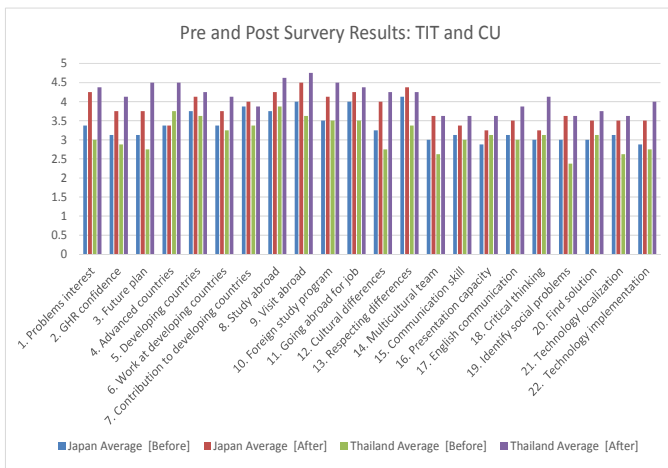


Fig. 1. Pre and post survey results

Table VI summarizes the pre and post survey results shown in Fig. 1. In the columns for "more than 3.0 before", the cells highlighted in yellows mean they had scores on more than 3.5. From Fig. 1 and Table VI, it is understood that both TIT and CU students have had high interests in other countries before talking the course. Also, after the course, TIT students have increased awareness on many of the indicators, and CU students had increased awareness on all indicators. Before the course, TIT students had higher awareness than CU students on many of the indicators, and after the course CU students had higher awareness than TIT students in many of the indicators.

TABLE VI. SUMMARY OF PRE AND POST SURVEY RESULT AND RATE OF CHANGE

Indicator category	Item in the graph	More than 3.0 Before		More than 3.5 After		BF	AF	$\Delta$ < 20 TIT	$\Delta$ < 20 CU
		TIT	CU	TIT	CU				
1) GA	1. Problems interest	✓	✓	✓	✓	TIT	CU	✓	✓
	2. GHR confidence	✓	✓	✓	✓	TIT	CU	✓	✓
	3. Future plan	✓	✓	✓	✓	TIT	CU	✓	✓
	4. Advanced countries	✓	✓	✓	✓	CU	CU	✓	✓
	5. Developing countries	✓	✓	✓	✓	TIT	CU	✓	✓
	6. Work at developing countries	✓	✓	✓	✓	TIT	CU	✓	✓
	7. Contribution to developing countries	✓	✓	✓	✓	TIT	TIT	✓	✓
	8. Study abroad	✓	✓	✓	✓	CU	CU	✓	✓
	9. Visit abroad	✓	✓	✓	✓	TIT	CU	✓	✓
	10. Foreign study program	✓	✓	✓	✓	CU	CU	✓	✓
	11. Going abroad for job	✓	✓	✓	✓	TIT	CU	✓	✓
2) MU	12. Cultural differences	✓	✓	✓	✓	TIT	CU	✓	✓
	13. Respecting differences	✓	✓	✓	✓	TIT	TIT	✓	✓
3) MT	14. Multicultural team	✓	✓	✓	✓	TIT	T/C	✓	✓
	15. Communication skill	✓	✓	✓	✓	TIT	CU	✓	✓
	16. Presentation capacity	✓	✓	✓	✓	CU	CU	✓	✓
4) CT	17. English communication	✓	✓	✓	✓	TIT	CU	✓	✓
	18. Critical thinking	✓	✓	✓	✓	CU	CU	✓	✓
5) TL	19. Identify social problems	✓	✓	✓	✓	TIT	CU	✓	✓
	20. Find solution	✓	✓	✓	✓	TIT	CU	✓	✓
	21. Technology localization	✓	✓	✓	✓	TIT	CU	✓	✓
	22. Technology implementation	✓	✓	✓	✓	TIT	CU	✓	✓

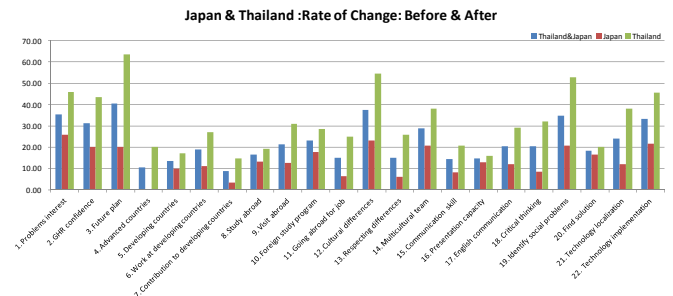


Fig. 2. Rate of change for TIT and CU

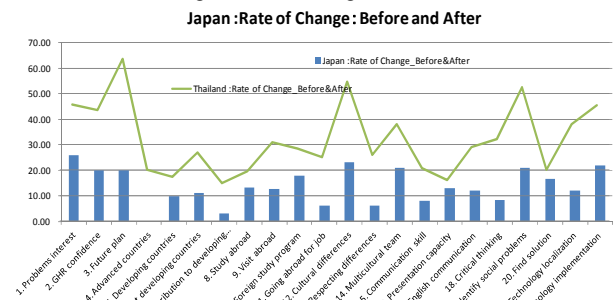


Fig. 3. Rate of change for TIT students with a comparison of CU students

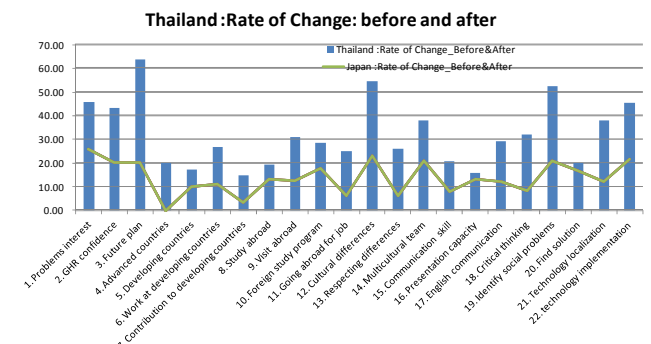


Fig. 4. Rate of change for CU students with a comparison of TIT students

Two columns from the right in Table VI show the summary of rate of change for TIT and CU. For rate of change, all indicators had increased (Fig 2). For items “3. Future plan”, “12. Cultural differences”, “19. Identify social problems”, rate of change was more than 50%. Rate of change for CU students are higher than TIT students on all items. For TIT students, motivations have increased for one or few items on all indicator categories. There was not change on interest on “17. Advanced countries”. For “11. Going abroad for job”, “13. Respecting differences”, and “7. Contribution to developing countries”, while the rate of increase is low, it is assumed that students kept the high motivation before and after the course (Fig. 2 and 3). For CU students, rate of change was higher in many of the items in all indicator categories (Fig. 2 and 4). Even though the rate of change with CU students is higher in all items than TIT students, growth level pattern is similar, except item “4. Advanced countries” and “17. English communication”, two of which only CU students had high level of increase (Fig. 3 and 4).

### 3) *Participants Observation*

In relation to indicator (1) Global Awareness, throughout the program including the CU's dispatch to Japan, many students have asked questions about each other's countries. For both TIT and CU students, since some of the students have visited each other's countries before the program, they could have picture some situations raised during the discussions. Students took the benefit to clarify some of the puzzles on what they have seen before through questions and commenting. After the face to face meeting, CU students expressed high interests in coming to study at TIT for their higher degree.

As for the (2) Multicultural teamwork, at TIT, one student per group was mainly making discussion with Chula on remote setting. In order words, some of the TIT students had barriers in communication in English thus then were not confident in oral communication. In the beginning, Japanese students tend to "type" rather than "talk". Also, some failed to communicate at all in oral setting. It came out in a way that foreign students at TIT probably were more outspoken than the Japanese students and they became the ones who communicate with the Thai students.

From the statement above, it is considered that (1) Global Awareness for students has been raised throughout experiences on course, including the formal classroom activities, informal discussion, and both remote and face-to-face meeting. For the (2) Multicultural teamwork, it seemed from TIT students that work sharing was important.

### C. *Summary of Results*

Results of learning outcomes are summarized as follows. TIT students had interest on selected issues and going abroad, realized the importance of understanding differences, and respecting others. They were confident on multicultural communication except presentation skill, and aware of the social issues.

CU students were interested in the PBL theme, highly motivated to visit other countries, aware of the importance of

respecting differences, confident about making presentation in English, and equipped with critical thinking to find the solutions on social issues.

Before the course, TIT students had higher interests than CU students on visiting abroad in general term, making contribution to developing countries, variety of communication skills and respecting differences, and problem finding and solving. CU students had higher motivation than TIT students on studying abroad in advanced countries. CU students had higher capacity on presentation and critical thinking than TIT students.

After the course, TIT students' interest on advanced countries had not changed at all. They were still not confident about communication and presentation capacity. TIT students kept high interests throughout the course on working abroad, making contribution to developing countries, and respecting differences.

CU students' motivation and awareness have increased remarkably, especially on their future plan, interests on social issues and finding locally adaptable solutions by respecting cultural differences. They thus became very confident on becoming global human resources. They have also equipped with higher level of English communication, multicultural teamwork, and critical thinking than before.

After the course, awareness level for both universities had increased but CU students had changed remarkably while change on TIT students was modest. Yet even though the rate of change between TIT and CU students is different, the growth pattern is somewhat similar.

Most of the students both from TIT and CU had increased the level of knowledge on selected issues, and developed necessary skills for critical thinking. Many of the students have established skills related to global awareness, multicultural teamwork, and multicultural understanding. Few students have developed skills related to technological localization.

### D. *Reasons and Finding*

Reasons and findings for the students' characteristics and learning outcome are discussed as follow. First, from the pre-analysis, it was clarified that both TIT and CU students were highly aware of the issues and motivated to visit abroad for many purposes. They were both aware of the importance in respecting others even before taking the course. In other words, because the course was set in a way to work together with university in other country, it attracted students who are interested in issues in other countries. For TIT students, they are interested in abroad in general, and one of the main purposes was to practice English communication skills. For CU students, many of them were attracted to Japan, and students were willing to know the selected issues about Japan through their yet to become friends of their age. That is to say, students who registered for the TIT-CU bilateral PBL program were already highly motivated to meet with people of different nationalities, and know about other countries, through multicultural communication.

Many of the TIT students were willing to make contribution to developing countries, because it is one of the big missions of the "Global Scientists and Engineers Course," the undergraduate curriculum to increase global competencies, which has been run for three years. Within the said course, students are trained to raise awareness on global issues from (1) listening to TIT alumni lectures working in global scale, (2) taking classes related to multicultural understanding, (3) attending problem finding and solving skills through workshops, and (4) participating group works and various kinds of hand-on experiments, many of which involve with international students as classmates.

Obviously TIT students' interest on advanced country did not change because of its counterpart. Instead, their interests on visiting and working at developing countries have increased because of the partnership with CU. TIT students' overall capacity for English communication and presentation did not improve, because half of the students who joined the class are from international students, two of which are fluent in English, which led the group discussion on Japan side for the whole time. The other group's leader belongs to English speaking club who always led the discussion. Thus instead of taking turns on discussion, it was always the same students who spoke up to Thai side, at least until they finally meet in person at the end of the program for final presentation. However, from the personal essays and observation during the non-formal interactions, all students from TIT and CU were very well mixed, thus it is assumed that students' multicultural communication skills have been improved.

CU students had higher motivation on studying abroad because for many students who have registered for the course were either ones who have already experienced studying abroad, or who were planning to study abroad in the near future. CU students' higher capacity of presentation and critical thinking could be considered as learning effects of CU's state of the art active learning practice at engineering department, along with CU's policy to conduct classes in English once there find the international students in the class. Based on their motivation and preparation, after joining the TIT-CU bilateral PBL program, their level of global awareness, multicultural communication skills, and critical thinking have all improved.

It is highly expected that reason for CU students' remarkable change on many items such as future plan, locally adaptable solutions, respecting differences has linkage with their visit to Japan as part of the program, while visiting Thailand part was only optional for TIT students. Since it was a first trial for both TIT and CU to conduct this joint program, many of the process was conducted on trial base, and thus difficult to plan the annual schedule. During CU's visit to Japan, besides a few group works to prepare the final presentations, students and instructors conducted site visits related to group work themes. Namely, CU students have visited transportation control center at Tokyo metropolitan police department, disaster prevention center, clean center as well as high tide center, attended with instructors, staff members and selected TIT students, some of which were group members of TIT-CU joint PBL program. During the

visit, CU students experiences local transportation, such as subway, train, and bus.

Although the level of growth is different between students from two universities, pattern of change is somewhat similar. It is probably because they had spent quite a few moments together for the same purpose, making proposal for the improvement of the selected issues incorporating each other's idea. The beautiful part relies on the fact that they made friends before they met face to face in Japan. It was quite a touching and waited-for-a-long-time moment when all group members, TAs, and instructors gathered together in Japan and made final presentations.

It should be emphasized here that as the course was conducted under multicultural PBL style using ICT, students have developed self-learning methods from their group-members of partner universities. Thus, students' achievement on skills on critical thinking, global awareness, multicultural teamwork, and multicultural understanding and technological implementation were all results of the whole process of active group work. Evidence could be shown from such sentences as "Attending the course was my great opportunity to get to know with foreigner and learn their culture and our differences"

## V. DISCUSSION

In previous literatures, it was elaborated that multicultural PBL could gain various competencies such as 1) critical thinking, 2) communication skills, 3) awareness and new ways of thinking, 4) respects and acceptance, and 5) tolerance. It was assured that all of those skills have developed through the TIT-CU multicultural PBL program for following reasons.

Specifically, 1) critical thinking was proven to be developed as the achievement of indicator (4) Critical thinking had confirmed. Students had collected data and evidences on both countries related to their group work themes such as climate, frequencies of typhoon, annual precipitation, number of floods, amount of waste generation and recycling, number of cars and means of transportation, and so forth, which were utilized for basic comparison of situation in Japan and Thailand. They further conducted surveys on relevant subjects as for the reference for their proposals. Students have developed self-learning methods through group works.

2) Communication skills, 4) respect and acceptance, and 5) tolerance have developed as indicators (2) multicultural understanding and (3) multicultural teamwork were gained by the students. After the remote-session started, students were requested to bring their findings in each session, and share their result of group discussion in plenary session. Through group discussion, they have shared their own countries' situations, at the same time learned the situation of partner countries. They did not have problems on unbalanced workload that was indicated in previous literature (Maken and Graaff, 2012), because English was used for common language, which is not a mother tongue of any of the students. Thus discussions were carried out in equal level, and tasks were shared evenly between two universities. On the other hand, they had to put many efforts than when they communicate in their native languages to understand each other, through which they have developed tolerance. Further,

by knowing the different situations of each country on the same issue, they have realized the importance of respecting and accepting differences, and learnt the good practices of each country.

3) Awareness and new ways of thinking have also gained as indicators (1) Global awareness, (5) Technology implementation have showed to be increased among many of the students. Expert lectures were provided at the very beginning of the course, followed by discussion among group members. Students have learned the background, issues, and current situations of selected themes through experts, and also from their group members, while conducting relevant studies on their own. A comment on essay symbolizes the way to learn differences on each other, “the same way of solution can solve the same problem in the other countries as well which might not work. That is why we have to study this subject”.

As the course was conducted under multicultural PBL style using ICT, even though students had not had extensive knowledge and information on relevant themes, without visiting the partner countries, students were able to learn from each other about other countries’ situations. Within the process, group members acted as primary resource persons for Japan and Thailand. In the process of knowledge sharing, while they have learned the situations of partner countries, they have developed the knowledge of their own country. It was a good experience for students to subjectively look at their own countries’ situation. Thus beside the expected skills gained with multicultural PBL, following three effects have observed.

First, students’ motivations to visit the partner countries were remarkably increased. By learning the situation of the partner countries from the group members, their interests on the subject have increased, which made many students willing to visit either Japan or Thailand. Many of the group members did actually realize the visits of partner countries as they wished, and further increase their interests to stay in longer period.

Second, overall interests on their partner countries have highly increased as well. During three months of the group work, students have developed good partnership, which resulted in desire to learn about culture, history, lifestyle, and other relevant issues about partner countries.

Third, as for CU students, by combining the remote session and actual site visits, students were able to deepen the knowledge on selected issues in other country. Since the students have conducted the studies and group works, the site visits were effectively utilized to confirm the actual situations, of which they have heard from their partners.

## VI. CONCLUSIONS

Conducting PBL itself needs various preparation and facilitation; added to the situation of remote setting and bilateral group-work was quite a challenge. Difficulties in communication, language barriers, and cultural differences, were some of the experiences students have faced throughout the group work. However, during the process of the group work, all students learned the differences of the themes among

the two countries, which are considered as highly respected and beneficial. From this bilateral PBL, it has been proven that there is always something to learn from each other, how the other country handles the situation, which can be incorporated to deal with issues in the future. Through this bilateral PBL program, the lessons learnt could be summarized as follows.

First, topics should be carefully chosen, more guidance on focus selection may be needed, so that students could find points of focus that they can make fair comparison between two countries. The three topics this time were ideal to captured interests from the students from the very beginning. However, one concern is on that the class probably had too many topics at one time so that students did not have enough time to deeply determine the theme and share among other groups. Thus the focus on just one topic should alleviate this issue.

Second, communication method and means should be carefully determined, especially for group work in English for non-native speakers. On CU side, English was not the problem because we screened students before class. Yet even so, Thai students have made improvement especially in the presentation in English. On TIT side, English is one of the big issues to take one step down from active participation on discussion, even though students have many knowledge and experiences to share with their international friends. Practical English training is considered to be mandatory for all engineering students at TIT. On the other hand, many ICT devices such as Polycom, Google Hangout, Google Drive, and Facebook were effectively utilized to connect the group’s tie.

Finally, based on this TIT-CU bilateral PBL, partnerships among students and instructors were created to share the fair, equal but different tasks, which is truly a rewarded part of the bilateral PBL program. Throughout the process, students discussed many issues and exchange ideas to broaden their perspectives, which is highly valuable to build network among international prospective engineers at the early state. Therefore, even with some difficulties those practice should be encouraged, throughout the PBL program one could have a lot of eye-opening event.

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