MEE002

Practical Manufacturing and Engineering Education in The Mechanical Engineering Course at Kokushikan University for Inter-university Partnership Programs

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Abstract

This article introduces examples of practical manufacturing education which use active learning methods in the mechanical engineering course at the school of science and engineering in Kokushikan University. Manufacturing industries are key industries for Japan and it is necessary to continuously develop these industries and train engineers to work in the industries. Therefore, our university focuses on manufacturing education throughout the four year university course and we teach specialist skills on practical themes. It was discovered that when active learning methods, for example project-based learning, were used they were effective and students became more interested in engineering.

Then Thailand is an extremely important country for Japanese and Japanese corporations, both of which have a strong affinity for the country. For the manufacturing industry, it is important that suppliers in Thailand provide parts as well as efficiently produce high-quality products, which would probably lead to not only future profits for these companies but also technological and economic development in both countries. Therefore, these corporations would like to train Thai engineers who can hold discussions with Thai suppliers, play leading roles in the company, and become manager candidates in the future. Our engineering education curriculum fits such engineer training. This article surveyed possibility of the engineer training by student exchange program based on an inter-university partnership agreement.

Keywords*:* Project-based learning, Practical manufacturing education, Student exchange program

1. Introduction

The Kokushikan University's School of Science and Engineering would like to promote inter-university partnerships with Thai universities. As for particulars, it is our opinion that it would be best to promote such a partnership in stages—mutual student exchanges and training, faculty exchanges, and research exchanges. One reason for this desire to develop partnerships is that there have been requests from several Japanese companies operating in Thailand, particularly manufacturers, for Japanese universities to allow Thai university students studying science to take part in short-term study programs in Japan where they could study various topics including manufacturing technology, the ideas underlying these technologies, and ethics. These companies would like these students to work at their local subsidiaries in Thailand after graduating. These requests are not limited to students studying technology; there are similar demands for students studying the humanities who could work as Japanese-Thai interpreters. We would like to develop a route for students from Thailand to study at the university for short periods of time and then having these students find work at Japanese companies operating in Thailand after graduating. We also think that on account of the recent trend toward globalization, being able to create multi-faceted partnerships with universities in Thailand, a particularly important partner in Asia, is extremely important for not only the university but also our students, faculty and researchers. It is our opinion that technical partnerships can be developed in various fields. Therefore this article summarizes possibility of cooperation among a Thai university, a company and a Japanese university. And also introduce PBL or Project-Based Learning education as a curriculum of our school which is useful for cooperation. And this article surveys possibility of a kind of construction of triangle cooperation of a Thai university and a Thai company and a Japanese university.

2. General conditions for Japanese companies

Thailand is an extremely important country for Japanese and Japanese corporations, particularly those in the manufacturing industry, both of which have a strong affinity for the country. For the manufacturing industry, it is important that suppliers in Thailand provide parts as well as efficiently produce high-quality products, which would probably lead to not only future profits for these companies but also technological and economic development in both countries. Therefore, these corporations would like to train Thai engineers who can hold discussions with Thai suppliers, play leading roles in the company, and become manager candidates in the future. As for Japanese-Thai interpreting, there are many Thais who, although skilled at conversational Japanese, are unable to accurately interpret during technical discussions, and there are concerns that even if these people were hired as interpreters they could not sufficiently do their jobs. It is necessary that employees serving as interpreters understand the ideas and values that underlie Japanese manufacturing as well as meanings of the related terms. Therefore, there are high hopes for short-term study at Japanese universities for both students studying science and ones studying the humanities. Until now, Japanese corporations have conducted in-house training for locally hired employees, which has included long-term training in Japan. Even though these companies spend money training these employees, some of the employees change jobs immediately after returning to Thailand or are no longer able to function in the organization. This system has resulted in many problems and not functioned well.

Many Japanese corporations have expressed an extremely strong interest in having Thai university students study at a Japanese university before hiring them. It is necessary to not only technology exchanges but also mutual understanding about each a culture each other.

3. Concrete partnership programs

Table 1 shows possible inter-university partnership programs. Our ultimate goal is to operate the program proposed in (1), but there is a slight barrier to implementing the program because it would require experience in running exchange programs. Therefore, it would be best to start with what can be done now. The cost for proposal (2) would be 120,000 yen annually, and research students could attend Kokushikan University for one year. Proposal (3) would be partnerships between labs at the two universities and be based on a common research topic, and one part of undertaking this research would be exchanges of teaching staff and students. For example, joint research could be conducted on the topic of the impact that differences between Japanese and Thai cultures have on design concepts. As one part of the research, students from your university could attend Kokushikan University as research students for short-term study. The length of study would be up to your university. The only expenses would be living and lodging expenses. Proposal (4) would entail various activities including teaching staff from each university visiting the other university and giving lectures. Of these various proposals, (2) is one that could be immediately implemented. This could be followed by proposal (3), which would require completing some in-house procedures related to applications, approval, etc., but this would likely not take that much time. We think it would be best to initially start the exchanges with (2) or (3), the goal of which would be to launch the program listed in (1) in two years.

Although slightly different depending on proposal (2) or (3) above, other possible activities include letting students sit in on lectures, holding group discussions among students, and conducting tours of Japanese corporations or other sites such as general museums or science museums. We can flexibly respond to requests. It would also be possible to have graduate students act as tutors, to provide support for daily life, and to undertake similar activities. Students studying the humanities who hope to become Japanese interpreters in the Japanese manufacturing industry could also study at the School of Science and Engineering, which is a major benefit for Thai students who come to the university for training. We would also like to work with other schools at the university, including the School of a humanities to move forward with preparations.

Table. 1 Possible inter-university partnership programs

(1)	Student exchange program based on an inter-university partnership agreement
(2)	Allowing research students to study at Kokushikan University
(3)	Partnerships between researchers or labs in particular fields of research
(4)	Faculty exchanges
(5)	Others

4. An Outline of the Manufacturing Education Curriculum

4.1 The Current Situation and Challenges for Manufacturing Education

Japan is natural resource poor and has to import most of the natural resources it uses from overseas. The only way that Japan can create wealth for Japanese society is to process imported raw materials into high value-added products. And also there is a attentiveness design from typical Japanese cuture as one of the added value in a products design. Therefore, we cannot allow our manufacturing industries to decline, and we need to continue to hand down our technologies as well as developing them. For this reason, institutions for higher education are increasingly expected by society to train engineers who will work in manufacturing industries. There are endless occurrences of accidents that destroy people's lives, involving machines which are supposed to serve people and society. For example, there are numerous tragic train and air accidents as well as accidents involving play equipment which is supposed to give joy to people. Parts of machinery always contribute to the causes of these accidents. Engineers create equipment and tools that are useful for people and society, but they can also contribute to major accidents if one mistake is made in their design. Therefore, there is no doubt that the training of high quality engineers who have practical skills is an important and urgent issue.

Kokushikan University focuses on practical education. Because the university is located in the middle of Tokyo, in order to differentiate ourselves from other institutions for higher science and engineering education which exist in the Tokyo Metropolitan area, we need to put our full energies into practical manufacturing education while at the same time tapping into the advantages of being located in the middle of Tokyo. Therefore, the Mechanical Engineering Course at the School of Science and Engineering provides practical education offering specialist skills, by focusing on manufacturing throughout the four years at the university. It seems that these are effective for the aforementioned university cooperation.

Fig. 1 is a diagram showing the areas of study that have to be covered by higher education institutions, by expressing the flow of primary, secondary and tertiary education on the cross axis and the expansion of education into specialized subjects on the vertical axis. The areas of study that have to be covered by science and engineering universities range from education which supplements primary and secondary education to practical, higher education that teaches specialist skills. In the past, practical, higher specialist skills education was given mainly by companies in the form of training courses for newly employed engineers or on-the-job training (OJT). Some of these educational activities for engineers are now conducted before students graduate from university, through internships and lectures by educational staff who used to work at companies. This is because many companies began to expect universities to train students to become engineers with practical skills so that they can start to work immediately after being employed. The reason for this is that companies no longer provide the long-term training programs for new employees that used to be provided in the bubble period (from the 1980s and to the mid-1990s). Instead, the new employees are given work to do as soon as they have completed a basic training course which lasts a few days. As shown in Fig. 2, higher education institutions began to provide practical education in addition to the specialized subject education that was traditionally taught. For example, many universities prepare curriculums which teach practical, advanced specialist knowledge as distinctive services, which had been taught at companies in the past. In Japan, where the child population is declining, universities which offer such distinctive education are likely to become more competitive because they increase the chance of their graduates obtaining jobs, generally speaking.

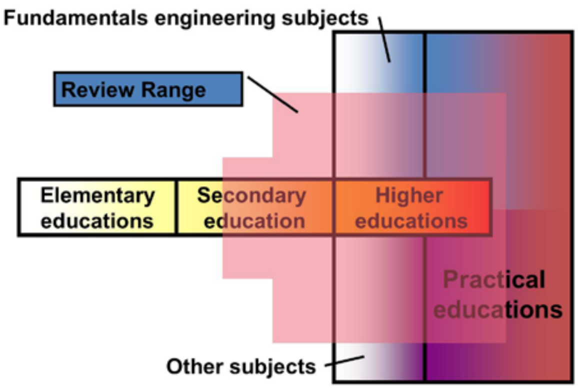

Fig. 1 The Cross Axis and the Vertical Axis of Engineering Education

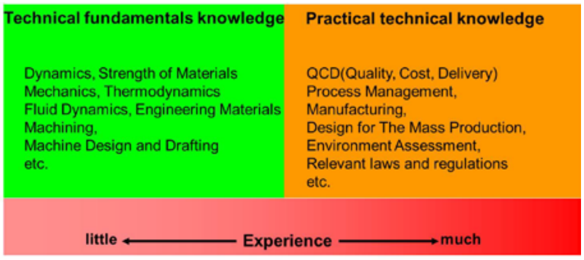

Fig. 2 Specialized Education at Higher Education Institutions

4.2 The Technical Skills Education System for Manufacturing Used in the Mechanical Engineering Course

Fig. 3 summarizes the education system for the Mechanical Engineering Course. In the course, the academic content to be learned is divided into four areas: mechanical dynamics, material dynamics, thermodynamics and hydrodynamics. The three concentric circles indicate the following: the central circle indicates the basic knowledge needed to learn mechanical engineering including science, mathematics, etc. taught in high schools. The medium-sized circle indicates the specialized subjects taught at the university. The largest circle indicates practical specialized education. The content of the course moves from the center of the circles outwards as students progress through the university.

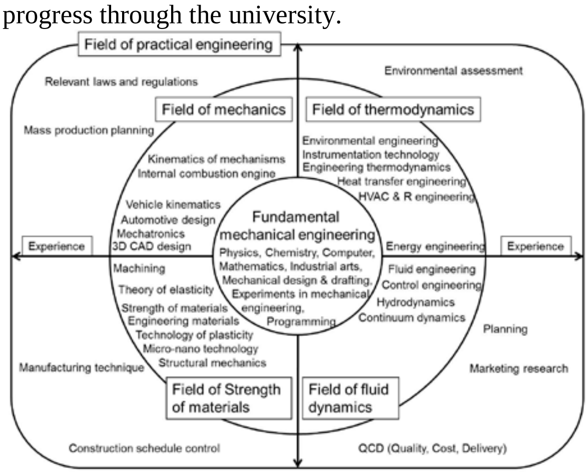

Fig.3 Manufacturing Education in the Mechanical Engineering Course at the School of Science and Engineering, Kokushikan University

Fig. 4 shows the year in which each manufacturing-related subject is taught. For first year students who have not been taught the specialized subjects, education on manufacturing is given based on the knowledge that the students obtained through science and technical skills education in high school. In the first year, the “Basics of Manufacturing A/B” are taught with the aim of increasing the creativity of students and to improve their ability to use basic engineering knowledge to make things. In the second and third year the students learn specialized subjects. The students are given themes for experiments and exercises through which they can check whether they have obtained expertise in the subjects. In particular, in the "Designing and Manufacturing Projects A/B/C/D," students are encouraged to follow the project procedures of "Plan," "Do" and "See." Meetings are also held and students present their project results, so that they can acquire presentation skills and be able to summarize and self-assess their projects. These experiences are eventually utilized in the graduation research that the students conduct in the fourth year.

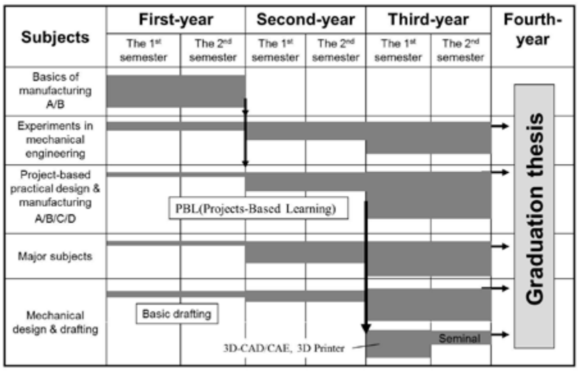

Fig. 4 Subjects Related to Manufacturing Taught in Each Year

5. Examples of Manufacturing Education Given in the First Year at the University

5.1 The Schedule and Outline

In order to study specialized science and engineering subjects, it is important that students have the ability to understand the connection between the technologies used in equipment and natural science theories. In particular, students who have just entered the university tend to have learned mathematics and physics as subjects needed for university entrance exams and most of them do not understand the connection between the subjects and how machines work. Therefore, in the first year, we find that it is effective to give manufacturing education using themes familiar to students, based on the knowledge that they had obtained before entering the university, such as the mathematics and physics they learned in high school. This section gives examples of lessons taught in "Basics of Manufacturing A/B" for first year students.

"Basics of Manufacturing A" is taught in 15 lessons in the spring term. "Basics of Manufacturing B" is taught in 15 lessons in the autumn term. Table 2 shows the connection between the themes taught and four specialized areas of study which are included in Fig. 3 above. The themes were chosen so that all the mechanisms can be understood using knowledge obtained in primary and secondary education. The goals were set so that students can create assigned products based on natural science theories, rather than through trial and error. The lecturer in charge of each theme guides the students so that they become interested in engineering knowledge that will be taught in the specialized subjects in the second and third grades. Table 3 shows an example of 15 lessons for "Basics of Manufacturing A." Five to seven lessons are given on each theme. Many hours are allocated for elaborating plans and designing so that students have plenty of time to think. After the first assessments of the designed and created products, the students are asked to redesign and modify the products based on the assessment results. This process is designed to increase the problem solving abilities of the students, which will then become useful in their graduation research.

Table 2 Content of "Basics of Manufacturing A/B"

Subjects	Theme	Related major subjects
Basic manufacturing A	Paper plane	Hydrodynamics
	Bamboo dragonfly	Fluid engineering Mechanics
Basic manufacturing B	Catapult	Mechanics Thermodynamics
	Spaghetti bridge	Strength of materials
	Coil spring car	Mechanicals Thermodynamics

Table 3 An Example of the Schedule for "Basics of Manufacturing A"

	Contents			Contents	
1st	Guidance		9th	Concept consideration	Bamboo dragonfly
2nd	Concept consideration	Paper plane	10th	Design and trial manufacturing	
3rd	Design and trial manufacturing		11th	Design and trial manufacturing	
4th	Design and trial manufacturing		12th	1st evaluation	
5th	1st evaluation		13th	Improvement	
6th	Improvement		14th	2nd evaluation	
7th	2nd evaluation		15th	Presentation	
8th	Presentation				

5.2 Examples of Lessons for Specific Themes

Fig. 5 shows the outline of the manufacturing of a model trebuchet, as part of "Basics of Manufacturing B." Students design trebuchets using the designated materials in the way they think is best. The cup is made of plastic. All the materials needed including the cups and pieces of wood are supplied by the school. The students design the angle at which the cup should be attached, the length of Component 3, the location of the wire which serves as the fulcrum, the angle at which Component 2 should be installed, and so on. They then make their model trebuchets. A bouncy ball is placed in the cup when testing the trebuchets. Students create the optimum structures that can throw a bouncy ball a certain distance, while reviewing what they learned in high school such as centrifugal force, the rotation of objects, kinetic energy and torque. Fig. 6 shows some examples of model trebuchets made by students. Fig. 7 shows a student evaluating the performance of his model trebuchet. Each product is different as it was made based on a design created by each student. In the evaluation, various tests are conducted in addition to checking the distance, so that students can learn more from the experiments. For example, they study the trajectory of the ball and the relationship between the height and the distance the ball achieved, by placing an obstacle in front of the trebuchet, as well as evaluating accuracy using a target.

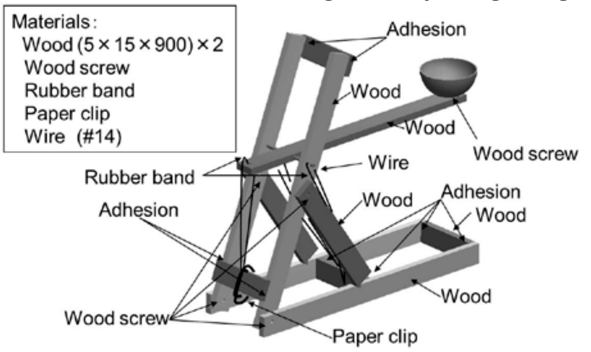

Fig.5 The Outline of the Model Trebuchet

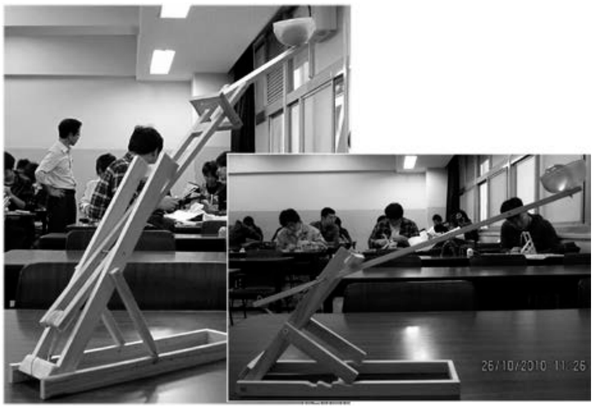
Fig.6 Examples of Trebuchets Made by Students


Fig.7 Evaluation of the Trebuchet That the Student Made

The next example is the "spaghetti bridge." Table 4 shows the specifications for designing a spaghetti bridge. Using dry spaghetti, each student designs and makes a model bridge by cutting spaghetti with a knife and sticking pieces together with instant glue. Through this experiment, the students deepen their understanding of strength so that they are ready to learn the specialized subjects categorized in material dynamics. In order to help the students to be ready for specialized subjects, supplementary teaching materials are used to explain the basic principles of material dynamics as shown in Fig. 8 and Fig. 9, as well as letting students explore the flexural strength of one piece of dry spaghetti, before they start designing their spaghetti bridges. Fig. 10 shows some examples of spaghetti bridges that students made. Because students were enthusiastically involved in the exercise, many products had structures that took into account the aesthetics as well as the strength.

Table 4 Specifications for Designing a Spaghetti Bridge

Design specifications
・Empty weight: 100 g or less ・Span of bridge: 600 mm or more ・Basic for evaluation: [Collapse load]／[Empty weight]

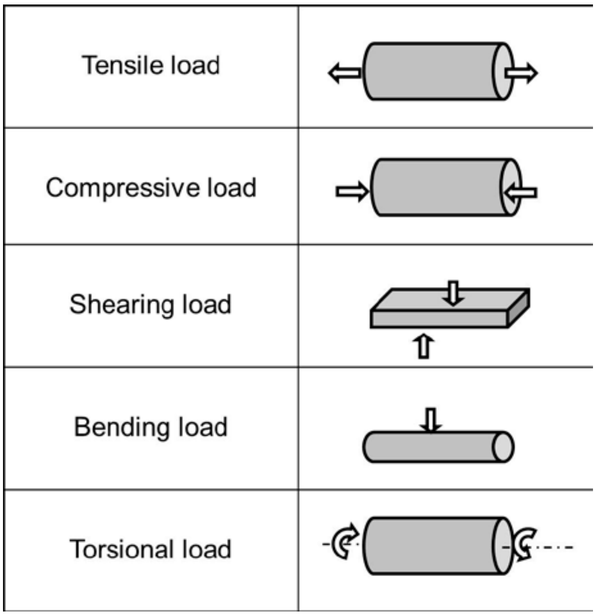

Fig. 8 An Example of the Supplementary Teaching Materials (Types of Loads)

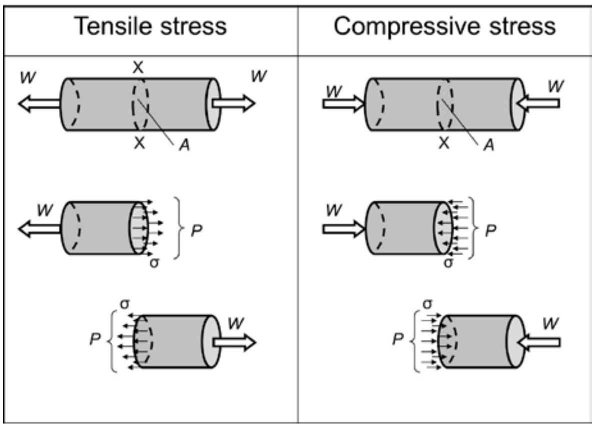

Fig. 9 An Example of the Supplementary Teaching Materials (Normal Stress)

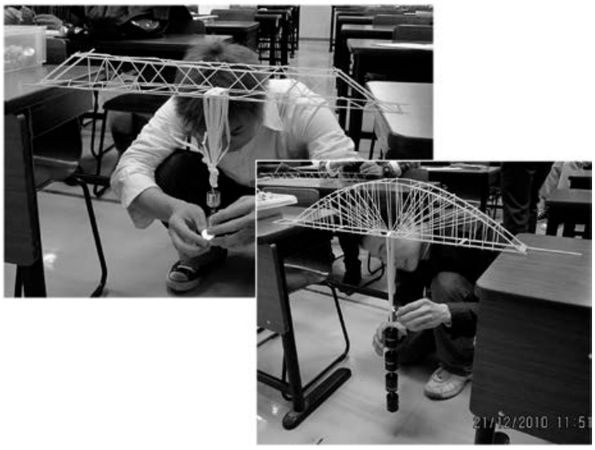

Fig. 10 Examples of Spaghetti Bridges Made by Students

5.3 Questionnaire Surveys for the Evaluation of Lessons

"Basics of Manufacturing A/B" have been taught from 2007 to 2010, and 50-80 students attended the lessons. Fig. 11, 12 and 13 show the results of the questionnaire survey for the evaluation of "Basics of Manufacturing A" conducted in 2010. Fig. 11 shows how satisfied the students were regarding the achievement levels for the lesson goals. Those who answered "very satisfied" and "moderately satisfied" accounted for 64% of the respondents, and only a small percentage of students said that they were not satisfied. This shows that the goals set for the series of lessons were generally appropriate. Satisfaction levels should increase further if the lecturers explain the goals and the aims of the lessons more clearly. Fig. 12 shows the level of student understanding regarding the content of the lessons. Those who answered "I understood well" and "I mostly understood" accounted for 74% of the respondents. This shows that the methods used in the series of lessons were highly effective in teaching the students. Fig. 13 shows the level of student satisfaction regarding the lesson content. Those who answered "very satisfied" and "moderately satisfied" accounted for 72% of the respondents. This shows that the lessons satisfied the majority of students.

Fig. 11 The Results of the Questionnaire Survey for the Lesson Evaluation (No. 1)

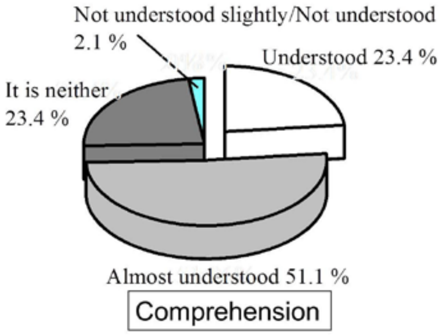

Fig. 12 The Results of the Questionnaire Survey for the Lesson Evaluation (No. 2)

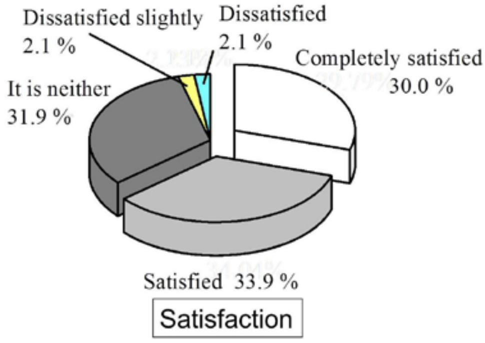

Fig. 13 The Results of the Questionnaire Survey for the Lesson Evaluation (No. 3)

6. Conclusion

In order to improve the methods for educating potential manufacturing engineers, the School of Engineering was reorganized into the School of Science and Engineering in 2007, and also new curriculums for teaching practical technical skills for first and second year students were developed and put into practice. Through the experience, it was discovered that the new curriculums made students more interested in engineering and that they were effective educational methods. These are useful for this cooperation education.

We would live to make progress, even if only slightly, in developing inter-university partnerships and create a framework for extensive mutual exchanges. We hope for your support in these efforts.