Project-Problem Based Learning and Internship in Mechatronics Department of KOSEN – KMITL

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KOSEN – KMITL was established with the aim of developing engineers who will be active mainly in Japanese companies that will be attracted to the Eastern Economic Corridor under the Thailand 4.0 policy. The KOSEN education system is characterized by a 5-year integrated education from the age of 15 to 20, a wedge-shaped education combining general and specialized subjects, and a combination of classroom lectures and experiments (we call it Lab work). By receiving specialized education centering on experiments and practical subjects from a young age, the human resources produced by KOSEN have the ability to think flexibly and absorb new knowledge even after graduation. Furthermore, KOSEN graduates have received a high reputation in the industrial sector over the 60-year history. We are transferring the KOSEN education system to Thailand. We are undertaking new challenges to develop a more advanced education system, including Project-Problem Based Learning (PBL) and collaboration with companies. PBL is conducted in the 3rd and 4th year, with the 3rd year students aiming to satisfy the given specifications, and the 4th year students starting from the procedure of problem identification. In addition, the internship is introduced as a compulsory subject. It is designed to recognize the relationship between the content of study and industrial application and simultaneously discover themes for graduation research. From the above background, the purpose of this paper is to report on the PBL and internship programs conducted last year for future education.

Keywords: *Industrial Collaboration, Internship, KOSEN Education System, Project-Problem Based Learning, Thailand 4.0*

Introduction

KOSEN – KMITL (King Mongkut's Institute of Technology Ladkrabang) was established in 2019 under the Human Resources Development Project in Engineering, Technology, and Innovation. This project aligns with the Thailand 4.0 policy, which supports investment and enhances the capabilities of the industrial sector in the country and region, especially in the Eastern Economic Corridor (EEC). It also focuses on developing human resources who are key in promoting targeted industries. In our institute, KOSEN – KMITL, the KOSEN education system, which involves the method combining lectures in the classroom and practices in the laboratory (it's called Lab work in the following), is being transferred from the Japanese KOSEN to educate practical engineers who will be able to contribute to the Thailand 4.0 policy. Mechatronics department was also established with the institute's opening; the first batch of students graduated in March 2024. Generally, the KOSEN students begin taking Lab work from the lower year to transform their lecture-based knowledge into practical skills effectively. In addition to Lab work, which lets students follow the instructed procedure, they take courses of Project-Problem Based Learning (PBL) 1 to 4 provided for 3rd and 4th year students. Unlike Lab work, the students need to consider a method and decide directions to solve assigned tasks by applying skills developed with past subjects in PBL 1 and PBL 2. This year, students made the equipment to satisfy the required specification in the topic that feeds balls into boxes. Here, there were balls with two materials and boxes with three sizes. Therefore, they must apply their skill of actuators, sensors, and controllers learned in Lab work to achieve the given goal. The experience through PBL 1 and PBL 2 makes their skill more practical, effectively solving actual social problems. Moreover, as the next step, the students are requested to find actual problems by themselves in PBL 3 and 4 to nurture their problem identification skills. Developing the original technology in industries highlighted by the Thailand 4.0 policy is essential. We collaborate with the company to conduct PBL 3 and 4 to let students know social problems. Also, an Internship is introduced to our curriculum for career education and to develop their skills. This paper will introduce unique educational concepts in the Mechatronics department at KOSEN – KMITL.

Curriculum Overview

Mechatronics department of KOSEN – KMITL has the curriculum to educate engineers who can develop robotic/mechatronic systems by applying their abilities in mechanical, electrical, and electronic, software, and network engineering. We have installed a "wedge-shaped curriculum" as shown in Figure 1 for the achievement of this objective (Aburatani, 2017) and are brushing up on the implemented educational system right now. The term "wedge-shaped education" has two meanings, one of which is the collaboration between general and engineering subjects, and the other is the collaboration between lecture and practical-based education. The former is effective for students who need to apply knowledge of a general subject (for example, mathematics, physics, and chemistry) to engineering subjects like dynamics in mechanical engineering and electrical circuits in electrical and electronic engineering. The latter can transform the knowledge of students into practical skills. This process is essential for a student who want to be an engineer and will be more important for current students who can learn knowledge by using web-based material and AI technology because practical subjects can help students to understand key concepts of engineering subjects and to achieve "symbol grounding" that can't realize with AI in current technology. Since Japanese KOSEN students acquire enough engineering skills through classes included in the curriculum, the KOSEN education system has received a great evaluation from industry for over 60 years.

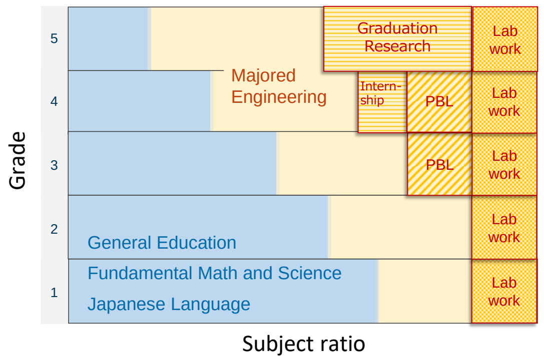


Figure 1 The curriculum structure of KOSEN – KMITL.

Figure 1 shows the allocation of Lab work, PBL, Internship, and Final Year Project with the school year. One of the new challenges in KOSEN – KMITL is to develop subjects of PBL that function to foster students' engineering skills, making them more useful for solving social problems, as discussed in our previous work on PBL implementation at KOSEN – KMITL (Luckanawat, 2024). Also, this education procedure enhances students' cognitive and research skills and cultivates critical soft skills such as teamwork, communication, and adaptability (Markham, 2011). This subject is designed to make KOSEN – KMITL distinctive compared to Japanese KOSEN. Beforehand, we need to mention the difference in employee hiring systems between Thailand and Japan. In short, Thai companies tend to expect students to have skills, while it seems Japanese companies emphasize high potential. Moreover, most Thai universities don't provide a supporting system for job-hunting. On the other hand, 100% of graduates who want to find a job from Japanese KOSEN can get it, and we have to build the same system in Thailand. To keep providing this system, we need to let students learn skills that make our graduates attractive to companies.

Subjects of PBL are conducted for 3rd and 4th year students. Then, they must take an internship course to recognize the application of engineering skills for industry between the 1st and 2nd semesters of the 4th year. This is another main topic of this paper.

After that, 5th year students tackle the Final Year Project with companies that accepted them for an Internship. Therefore, we summarize that the biggest feature of KOSEN – KMITL is strong collaboration with companies. The Details of the Final Year Projects conducted in cooperation with companies have been reported in our previous study (Sakonkanapong, 2024).

Project-Problem Based Learning (PBL) in 3rd Year

Project-Problem Based Learning (PBL) is implemented to the curriculum for 3rd and 4th year students of the Mechatronics department to transform their engineering skills, which have been acquired in lectures and Lab work. The 3rd year students take PBL 1 and 2 in each semester, then, 4th year students take PBL 3 and 4 in each semester. Each PBL has 100 minutes per week for 15 weeks. The purpose of PBL for 3rd-year students is to be more familiar with mechatronics engineering. In general, mechatronics engineering involves the five elements of sensor, actuator, controller, power source, and mechanism. Students are requested to fabricate the equipment by applying their fundamental skill of the five elements learned before taking PBL. In Lab work, they just need to follow the instructions to conduct it, but they are forced to consider and select components that can achieve specific performance in PBL. We consider that this is the largest difference between Lab work and PBL.

In Academic Year (AY) 2024, 3rd year students were divided into 8 groups (each group has 5 members), then, they were assigned to develop the equipment for sorting balls. The required specification is following.

- Metal and glass balls of 12 mm of diameter must be sorted.
- The size of box (50 mm, 40 mm, and wrong size cubic) must be detected.
- The system size must be within 800 mm × 500 mm × 500 mm.
- Only one Arduino Mega is available as a microcontroller.
- Only one power supply with 12 V and 5 A is available.
- The budget must be lower than the upper limit.

This was the second year for the same topics, but the specifications provided for students were sophisticated with the experience of AY2023. In detail, we focused on only one specification to properly guide students, accelerate progress, and increase completion (in the last year, 8 groups were further divided into four groups each. Each of the four groups was assigned a different specification). Also, the product of the microcontroller and the power supply were designed to be ordered easily. In addition, they were instructed how to craft the flame by using aluminum profiles. These modifications were effective in improving the degree of perfection.

The rough schedule of PBL 1 and 2 is shown in Figure 2. The goal of PBL 1 in the 1st semester is to determine the concept by drawing the 3D CAD model to satisfy the specification. 3D CAD models of the two groups are shown in Figure 3. Before that, students learned methods for brainstorming to discuss the concept with group members. Then, at the beginning of several weeks of PBL 2 in the 2nd semester, they were asked to submit a Gantt chart of their project and a BOM (Bill of Materials) to clarify the progress.

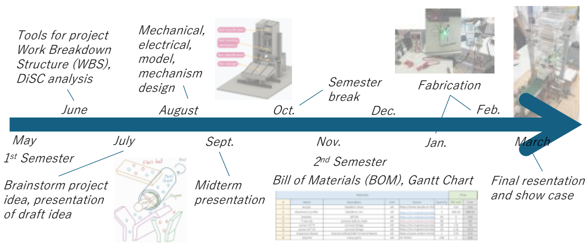
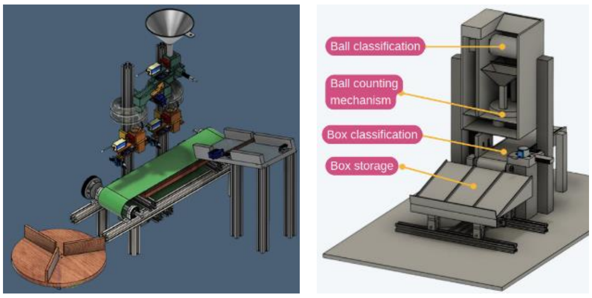


Figure 2 The annual schedule of PBL 1 and 2.



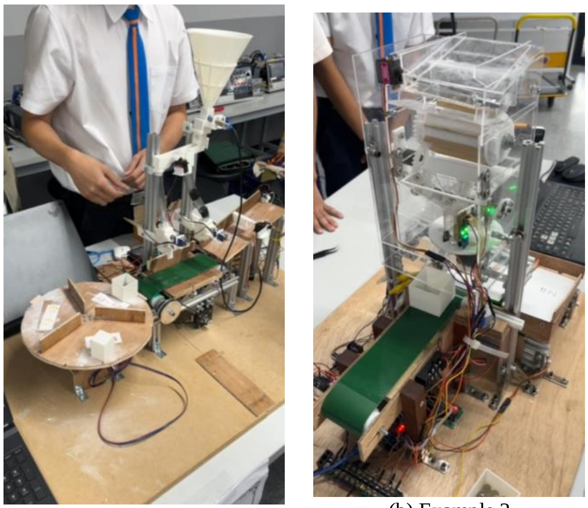
(a) Example 1 (b) Example 2
Figure 3 Examples of designs in PBL 1 and 2.

Photos of representative fabricated equipment with two groups are shown in Figure 4. These groups succeeded in manufacturing equipment that can complete all assigned tasks. Regardless, the procedure of tasks wasn't specified by teachers, but most groups adopted the following procedure.

a) The operator sets the balls and the box in the initial place.
b) Balls are sorted by materials (metal and glass).
c) The size of the box is detected to determine the number of balls that must be filled (This number was designated).
d) A box is moved to the filling location with a conveyor belt.
e) The designated number of balls of each material is filled into a box.
f) A box is transported to a place for each size.

The significant difference among groups was seen in the mechanism for detecting and sorting balls. The group with Figure 4(a) utilized a proximity sensor to detect the coming of a ball and its material. Then, a servo motor regulates opening and closing the gate for changing routes. After feeding balls to pipes, the designated number of balls are put into a box with a solenoid valve. More than half of the group applied a proximity sensor to detect the material of balls.

The machine in Figure 4(b) has a unique mechanism to sort balls. The cylinder with brown parts is located at the top of equipment. This cylinder has an embedded magnet inside. Therefore, glass balls fall in the front while attracted metal balls fall in the back.

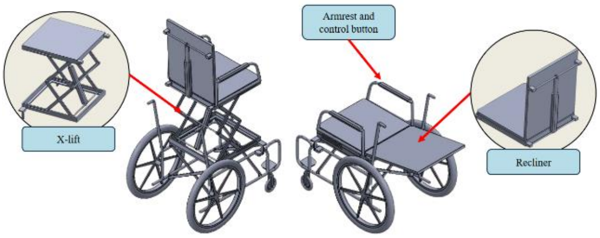

(a) Example 1 (b) Example 2
Figure 4 Examples of fabricated equipment in PBL 1 and 2.

As shown in these figures, students utilized many kinds of sensors (IR sensors, proximity sensors), actuators (DC motor, servo motor, stepper motor, solenoid valve), jigs fabricated with a 3D printer, a wooden board, an aluminum profile, and a microcontroller. Also, they needed to write a 3D model with 3D CAD. Every group decided a person in charge of subdivisional works, for example, making the frame, electrical wiring, programming of the controller, and so on.

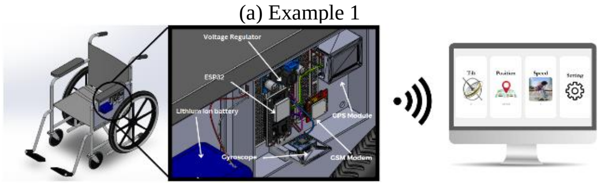
Project-Problem Based Learning (PBL) in 4th Year

Courses of PBL 3 and 4 are offered 4th year students in the 1st and 2nd semesters respectively. In these courses, students collaborate with companies to solve more practical social issues based on the experience gained from the projects conducted in their third year. Furthermore, while specific specifications were provided in the 3rd year, the 4th year begins with the discovery of issues. In this way, in addition to the problem-solving skills acquired in the third year, problem-finding skills are also developed. These abilities seem to be essential to survive for humans after implementing AI technologies to industries.

Last two years (AY2023 and AY2024), we collaborated with MATSUNAGA, the company that holds the largest market share of wheelchairs in Japan, to develop a smart wheelchair. For considering the innovative idea, students engaged in group work to find problems with existing wheelchairs through brainstorming in the first half of the 1st semester. Then, they spent the remaining period of the semester to make their project concrete by making a BOM, a Gantt chart, and a model of 3D CAD similar to PBL 1. In the 2nd semester, they began to fabricate the prototype after modifying the model of 3D CAD and receiving ordered materials and components. Models of 3D CAD with two groups are shown in Figure 5. We can roughly categorize them into groups that focus on customization with software and hardware aspects, so representative groups for each are chosen as examples.



(a) Example 1

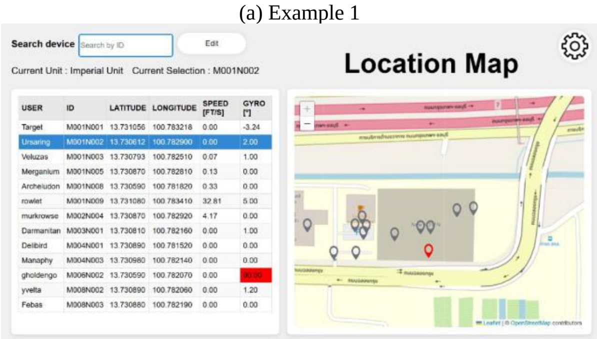


(b) Example 2

Figure 5 Examples of designs in PBL 3 and 4.

The group which built a wheelchair with Figure 5(a) and Figure 6(a) proposed improvements focusing on addressing the convenience when a caregiver provides support, situations where the user takes an object from a high place, and comfort when the user is seated. The X-lift is used as the mechanism, which is based on the mechanism made in the first semester of the third year in machinery practice.

(a) Example 1



(b) Example 2

Figure 6 Examples of fabricated equipment in PBL 3 and 4.

In contrast, the group that fabricated the wheelchair of Figure 5(b) and Figure 6(b) focused on the advanced function with software technology. Their wheelchair is equipped with a GPS module and a Gyroscope mainly to detect when the wheelchair is falling. This function enables the caregiver to check the location and the condition of the user remotely. Therefore, the developed system has the potential to solve the problem of the caregiver shortage in the welfare industry.

Internship

The 4th year students in KOSEN – KMITL must participate in the internship during the semester break between the 1st and 2nd semester in October. It differs from the Japanese KOSEN in duration and type, compulsory or elective. The duration of the internship in KOSEN – KMITL is longer than that of Japanese KOSEN (one or two weeks is common). However, it is shorter than the normal one for students at universities in Thailand, which is generally 3 or 4 months. To compensate for the shortage of time, 5th year students in KOSEN – KMITL conduct final year projects, such as graduation research, in Japanese KOSEN. In a Final Year Project, a student or a group of students carry on research with a company that accepted those students to solve a problem that the company is facing. Therefore, 4th-year students need to discuss with the company's engineers to decide the project's direction in the 2nd semester. This structure has been adopted to educate students as practical engineers. Also, we think that it is a valuable method for enhancing the effectiveness of education at KOSEN that prioritizes hands-on skills.

Table 1 shows the companies that accepted students for internships in 2024. Topics of internship are widely spread, such as mechanics, electrical and electronic, and information engineering. Since our internship is to be followed by a Final Year Project, the topic should be matched to the expertise of an advisor of KOSEN to properly guide students and enhance project outcomes. Therefore, sufficient discussion with companies is necessary before assigning students to enrich the achievement of faculty members. We have an Industrial Linkage Team that is a unique team to enhance the collaboration between companies and KOSEN – KMITL. It is imperative to accumulate experience and build a better structure for this educational scheme.

Table 1 The list of collaborated companies in the internship.

A.I. TECHNOLOGY COMPANY LIMITED
AppliCAD PLC
DENSO Innovative Manufacturing Solution Asia Co., Ltd.
DMG MORI
Fujikura Electronic Components (Thailand) Ltd.
Hitachi Astemo Korat Brake System Ltd.
Honda R&D Southeast Asia Co., Ltd.
ISUZU ENGINE MANUFACTURING CO.,(THAILAND)LTD.
Kanemitsu Pulley Co., Ltd.
Mitutoyo (Thailand) Co., Ltd.
Okuma Techno (Thailand) Ltd.
OS Design
Runexy(Thailand) Co.,Ltd.
SIAM KUBOTA Corporation Co., Ltd.
Thai Kikuwa Industries Co.,Ltd.
Thaioil Energy Service.Co.Ltd
Toyota Tsusho NEXTY Electronics (Thailand) Co., Ltd.
YASKAWA ELECTRIC THAILAND CO. LTD.

Conclusions

This paper has described PBL and internship in KOSEN-KMITL, which are implemented to make students' engineering skills more practical. The students' productions showed their ability and potential. Installing those subjects effectively raised not only engineering skills but also skills of time management and team building for students. This effective education method should be reintroduced to Japanese KOSEN. However, we couldn't ensure enough fabrication time for both PBLs due to the allocation of the budget schedule for the last academic year. The early budget allocation is essential to improve the quality of products and to release them from the excess anxiety with deadlines in those practical subjects.

On the other hand, KOSEN has the feature that 100% of students who want to find a job will find a job position before graduation. For the achievement of this goal, we need to promote the KOSEN educational system for industrial companies to ensure enough job positions, regardless of its short history and the cultural gap. Additionally, companies in Thailand have a skill-based hiring style, so the concrete development of students' practical skills is more important than Japanese KOSEN. From this viewpoint, we can say the installation of these kinds of subjects is a valuable trial in KOSEN-KMITL.

Acknowledgements

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