CURRICULUM AND IMPLEMENTATION OF KOSEN ENGINEERING EDUCATION AT KOSEN-KMITL, THAILAND

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ABSTRACT

Japanese College of Technology (known as "KOSEN") for engineering education, starting at the age of 15, is Japan's original five years tertiary education school has played important roles in fostering innovative engineers in Japan in the last fifty years. In May 2019, the first KOSEN in the Kingdom of Thailand, KOSEN-KMITL, was opened at King Mongkut's Institute of Technology Ladkrabang (KMITL) under the mutual collaboration between Thailand and Japanese stakeholders to foster innovative future engineers as Thailand's industrial human resource development project. The KOSEN-KMITL is established to provide engineering education as same as Japanese NIT's KOSEN and is operated by KOSEN-KMITL's Thai faculties and Japanese KOSEN experts. In order to ensure educational equivalency between KOSEN-KMITL and Japanese NIT KOSEN, its curriculum is designed based on NIT's "Model Core Curriculum (MCC)" that covers learning contents with specific attainment target levels, students' professional and generic competencies, curriculum design policy, educational approaches, quality assurance measures, etc. as the minimum standard for NIT's KOSEN. In this paper, KOSEN engineering education starting at KOSEN-KMITL, including extracurricular activities and international collaboration, is reported. It is shown that the KOSEN-KMITL curriculum well matches with the CDIO standard and syllabus. Since KOSEN-KMITL is a newly opened school in collaboration with 51 NIT's KOSEN colleges, many educational challenges are being implemented. The details of the comparison result with a subject mapping based on educational outcomes and the progress of KOSEN education in Thailand are presented.

KEYWORDS

KOSEN education, Continuous Improvement of Education, Curriculum Design, Standards 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12

INTRODUCTION OF KOSEN EDUCATION

KOSEN Education

KOSEN starting from the 1960s, is a 5-year Japanese style College of Technology for engineering education. "KOSEN" is an abbreviation of the Japanese word "Koto-senmon-gakko" meaning College of Technology, where "Koto" stands for high-level and" Senmon" stands for major (engineering). Figure 1 shows the Japanese education system and KOSEN. At present, there are 57 KOSEN nationwide in Japan: 51 national KOSEN run by the National Institute of Technology (NIT), three prefectural/municipal KOSENs, and three private KOSENs. Most of the KOSENs provide engineering education programs for associate degrees.

KOSEN was first founded to meet the strong demand from industry for practical engineers in 1962 during rapid economic growth in Japan. Presently, about 1 percent of the lower secondary school graduates at the age of 15 years enter the KOSEN. Since secondary education in Japan covers junior high school (lower-secondary) and the high school (upper secondary) followed by tertiary education, this 1 % of students in the middle of secondary education jump into tertiary education and start high-level engineering education.

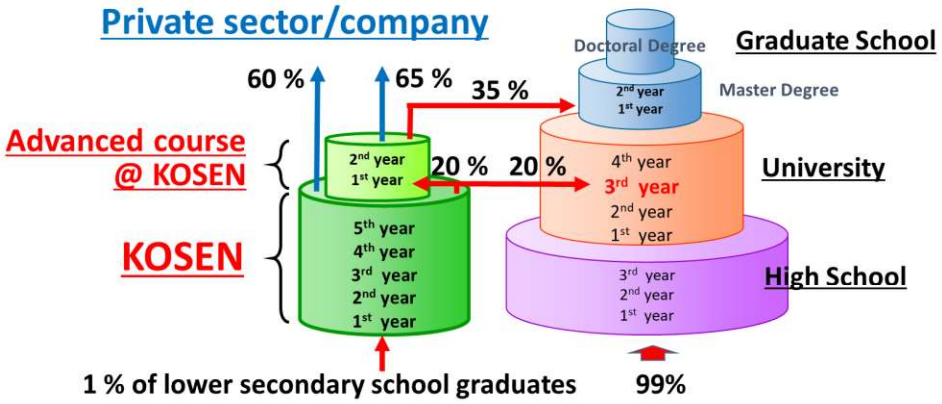

Fig. 1 Japanese education system and KOSEN

As lower secondary school graduates enter KOSEN, the KOSEN curriculum basically covers an upper secondary education. However, five-year consistent engineering education, including project-based learning/academic research works, enables the students to be practical and innovative engineers effectively. The KOSEN curricula are designed to provide scientific knowledge, experiments, workshop training to foster practical manufacturing skills of students. KOSEN education has been highly regarded by the public, by industries, and by international institutions. As mentioned, the outstanding characteristic of KOSEN education is its five years (regular course as college part) of consistent early engineering education starting from the age of 15 years; the KOSEN is an early engineering education and a fast track to foster high-quality young engineers.

Table 1 shows a summary of NIT KOSEN. At present, there are 51 NIT KOSEN (55 campuses), and approximately 50,000 students from the age of 15 to 22 years are enrolled. It should be noted that the number of students who graduate from both regular and advanced courses of KOSEN is about 10 % of the total number of new graduates of engineering departments, including junior colleges, universities, and graduate schools in Japan.

Table 1 Summary of NIT KOSEN

	Description	remarks
Number of NIT KOSEN	51 Colleges (55 Campuses)	
Admission requirement	Completion of lower secondary education	
Degree to be obtained	5-year regular course: Associate degree	
	2-year advanced course: Bachelor degree	
Number of Students	48,509 (5-year regular course: 185 departments), 2,995 (Advanced course: 105 courses)	As of May 2018

Model Core Curriculum and CDIO Syllabus & Standards

With the development of society, education and learning have changed significantly over the last decades. To improve the preparation of KOSEN students to meet these high demands in a rapidly changing world and technology, "Model Core Curriculum (MCC)" for 5-years regular course has been developed as an educational framework for all NIT KOSEN (National Institute of Technology, 2019). The MCC is designed in reference to international standards (e.g., the criteria of ABET: Accreditation Board for Engineering and JABEE: Japanese Accreditation Board for Engineering Education) as well as the CDIO Standards and Syllabus (The CDIO Initiative, 2019a, b). Table 2 shows the contents of the MCC and the specified knowledge, expertise, and competencies. The MCC consists of three parts. Chapter 1 covers *the rationale* and educational modalities based on the MCC. Chapters 2 to 4 describe the required knowledge, expertise, and competency for engineers. Quality assurance functions, including curriculum design, educational approaches, faculty developments, etc., are covered in chapter 5. The MCC provides the NIT's concept of curriculum design, pedagogical approaches, quality assurance measures, etc. as well as required learning contents. To archive these targets, 5-year long educational plans are well designed, and several courses integrated into educational themes as subject module blocks are given in parallel and consecutively depending on the students' development. It should also be noted that each NIT KOSEN develops its original educational programs reflecting regional characteristics as well as educational assets to provide the students with contextualized learning opportunities, in addition to the MCC. Therefore, KOSEN-KMITL also provides its original programs.

Many educational studies have been focusing on the comparison between CDIO Standards & Syllabus (CDIO Initiative, 2019a, b) and other educational frameworks and programs (Malmqvist 2009), (Alcion & Levy, 2009), (Cloutier, Hugo & Sellens, 2010), (Rynearson, 2011), (Aburatani 2019). Table 3 shows a comparison between NIT MCC and CDIO Standards and Syllabus. As listed in Table 2, the required knowledge, expertise, and competency are provided in the MCC chapters 2, 3, and 4; the CDIO Syllabus is covered by these chapters. Especially for implementation of Conceive, Design, Implement, and Operate, "IX. Integrated Learning Experience & Creative Thinking" in chapter 4 includes these mostly. NIT KOSEN provides the students with subjects/programs such as research work, project-based learning, etc. based on the concepts of "Engineering Design" and "Monozukuri education." Notably, the research work in the 5th-year grade that requires the engineering design approach and C-D-I-O process is the uniqueness of KOSEN education and plays a very important role. The concept of CDIO standards providing the fundamentals for a program is covered through the MCC. Therefore, NIT MCC correlates highly with both CDIO Standards and Syllabus. However, the MCC has a weak correlation with CDIO syllabus 4.2 (entrepreneurship part), because this part is set to belong to the education at the advanced course after the five-year regular course at each KOSEN colleges.

Table 2. The Contents of the Model Core Curriculum

Chap.	Contents	Categories
1	Educational Modalities and the Model Core Curriculum	1.1 Competencies Relating to Engineer Education 1.2 Achievement Targets 1.3 Approaches for Engineering and Interdisciplinary Programs
2	Basic Competency for General education and Basic Engineering	I. Mathematics, II. Natural Science, III. Humanities & Social Sciences, IV. Basic Engineering
3	Knowledge, Expertise, and Competency for Major engineering education	V. Knowledge and expertise for each Engineering field, VI. Engineering Experiments & Practice Competencies
4	Interdisciplinary Competency for Engineers	VII. General Skills, VIII. Mindset and Direction (Personality), IX. Integrated Learning Experience & Creative Thinking
5	Quality Assurance Functions of the Model Core Curriculum	5.1 Curriculum Design and Syllabus Based on MCC, 5.2 Efficient and Effective Evaluation Method for Students' Attainment Levels, 5.3 Collaboration on educational contents and teaching methods 5.4 Systematic Implementation of FD/SD 5.5 Mechanisms for Students' Self-Directed Learning 5.6 Evaluation and continuous improvement of the Model Core Curriculum

Table 3. The Contents of Model Core Curriculum (MCC) and CDIO Syllabus and Standards

MCC Chapter and contents		CDIO Syllabus	CDIO Standards
1	Educational Modalities and the Model Core Curriculum		1,
2	Basic Competency for General education and Basic Engineering	1.1, 1.2 3.3 4.1, 4.2	2, 4 1, 7, 11
3	Knowledge, Expertise, and Competency for Major engineering education	1.3 2.2, 2.3 4.3, 4.4, 4.5, 4.6	2, 3, 5, 6, 1, 7, 11
4	Interdisciplinary Competency for Engineers	2.1, 2.2, 2.3, 2.4, 2.5 3.1, 3.2 4.1, 4.3, 4.4, 4.5, 4.6 4.2	2, 3, 5, 7, 8, 1, 11
5	Quality Assurance Functions of the Model Core Curriculum		1, 3, 8, 9, 10, 11, 12

Note: Underlined numbers indicate a weak correlation.

KOSEN EDUCATION AT KOSEN-KMITL

In May 2019, KOSEN-KMITL was opened at King Mongkut's Institute of Technology Ladkrabang (KMITL) under the mutual collaboration between Thailand and Japanese stakeholders to foster innovative future engineers in Thailand. At newly opened KOSEN-KMITL, twenty-four students selected nationwide are studying in the "Mechatronics"

department. Table 4 shows a comparison between NIT KOSEN and KOSEN-KMITL. The KOSEN-KMITL is established to execute engineering education as same as Japanese NIT KOSEN, and KOSEN-KMITL provides the students with the latest NIT's MCC based curriculum.

Table 4. A comparison between NIT KOSEN and KOSEN-KMITL

* As of AY 2019.

	MCC Curriculum	Total Credits	Language	Number of depts. at each KOSEN	Class size (per class)
NIT KOSEN	○	>167	Japanese	3 to 5	40
KOSEN-KMITL	○	>186	Thai, English, + Japanese	1 (Mechatronics*)	24*

Three departments (Mechatronics Engineering, Computer Engineering, Electrical, and Electronic Engineering) will be operated with a full student capacity of 48 for each department from 2024.

KOSEN-KMITL Curriculum Design and Introductory subject modules

KOSEN curriculum is designed to provide the students with a well-balanced General Education subjects (Liberal arts, Science and Mathematics) and Major Engineering subjects in accordance with students' development. Figures 2(a) and (b) show the basic concept of the KOSEN curriculum structure of the 5-year regular course and actual one for KOSEN-KMITL. In a wedge-shaped structure (Fig. 2 (A)), which has been used to explain KOSEN curricula, the number of major engineering subjects gradually increase. The concept of the KOSEN-KMITL curriculum is also based on this wedge-shaped structure. However, a sufficient number of general engineering subjects as introductory subjects are placed in the first year intensively.

There are two reasons for this modification. First, although these wedge-shaped curricula provide sufficient learning opportunities for the students to study theoretical knowledge and to conduct scientific/engineering experiments, workshop training, and research work to develop practical skills, KOSEN education also faces various changes in education and learning. Engineering education is a long process and needs to be much more proactive to changes in technology, teaching, and learning. These introductory subjects provide the students with a foundation not only for engineering majors education but also for learning and for developing the mindset as engineers.

Second, as KOSEN-KMITL is a newly opened school with only one class, it is necessary and essential to show and to teach the students what is "Engineering," what are "Engineers," and what is "KOSEN" in class. In KOSEN, the senior and junior students collaborate together through school events, extracurricular activities, etc. This relationship is an essential part of KOSEN's hidden curriculum and formation of KOSEN students' mindset. Without the presence of senior students and any graduates who represent school identities, these introductory general engineering subjects play an important role in establishing students' mindsets as KOSEN students in addition to other school activities.

Figure 3 shows these introductory general engineering subjects and modules for the first and second years semester 1: Introduction to Engineering Approach I and II, Introduction to Engineering Design, Reverse Engineering I and II, and Lab work I, II, and III. The engineering design module provides students with the concept of Engineering design and Monozukuri (manufacturing) in KOSEN to solve problems and develop products. "Reverse Engineering I and II" as well as Lab work subjects provide students with hands-on opportunities to learn and

to examine technologies in products to deepen their understanding of engineering. "Intro. to Engineering Approach I and II" and "Intro. to Engineering Design" cover the basic knowledge and logical approaches for problem-solving, including 21st Century skills, 4Cs, and PBL for tackling engineering problems. In these subjects, the KOSEN education, Engineering, and roles of Engineers are shared and discussed repeatedly to form their identity as newly establish KOSEN-KMITL students. Figures 4 (a) to (f) show pictures of these subjects.

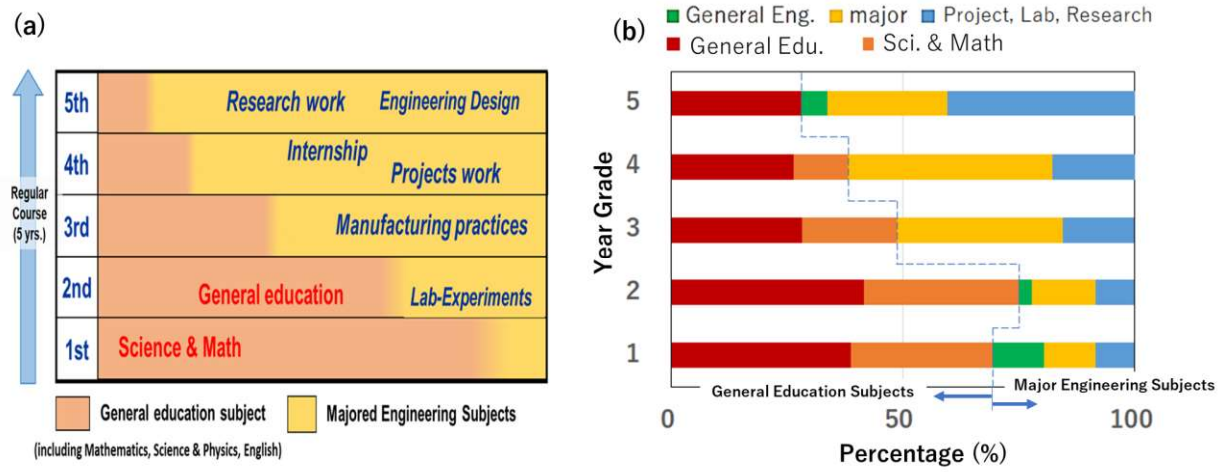

Fig. 2 Basic concept of (a) KOSEN curriculum structure and (b) KOSEN-KMITL curriculum

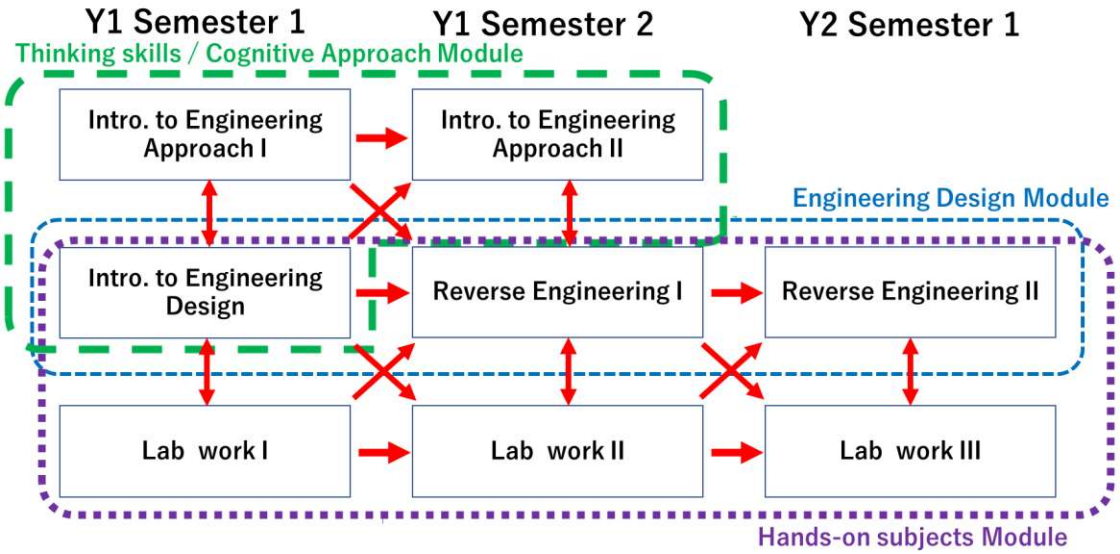

Fig. 3 Introductory general engineering subject modules for the first and second years

KOSEN education and 4Cs

Figures 5 show examples of PowerPoint slides used in the "Introduction to Engineering Approach" class. The left slide shows the relationship between 4Cs (Creativity, Critical Thinking, Collaboration, and Communication) and KOSEN education. In addition to 4Cs, "Continuity," which is a crucial factor in KOSEN education, is added. Continuity in engineering learning experiences is key to develop students' skills and understanding, and to guide them

to new ideas, challenges, and innovations. As 5-year of KOSEN education starting from 15 years (middle adolescence) provides the students with many opportunities, these approaches encourage students' challenges at KOSEN-KMITL in Thailand.

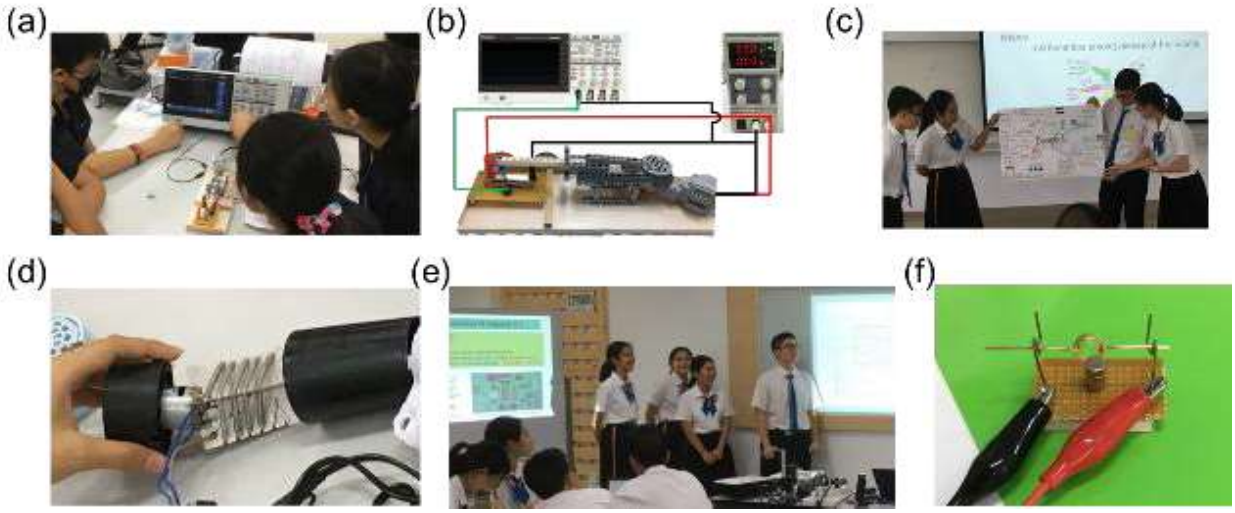

Fig. 4 Pictures of (a), (b): Lab work class (Crank and displacement measurement), (c) Engineering approach (Mind map), (d), (e): Reverse Engineering (Hairdryer disassembling and analysis), and (f): Engineering design (Coil motor development)

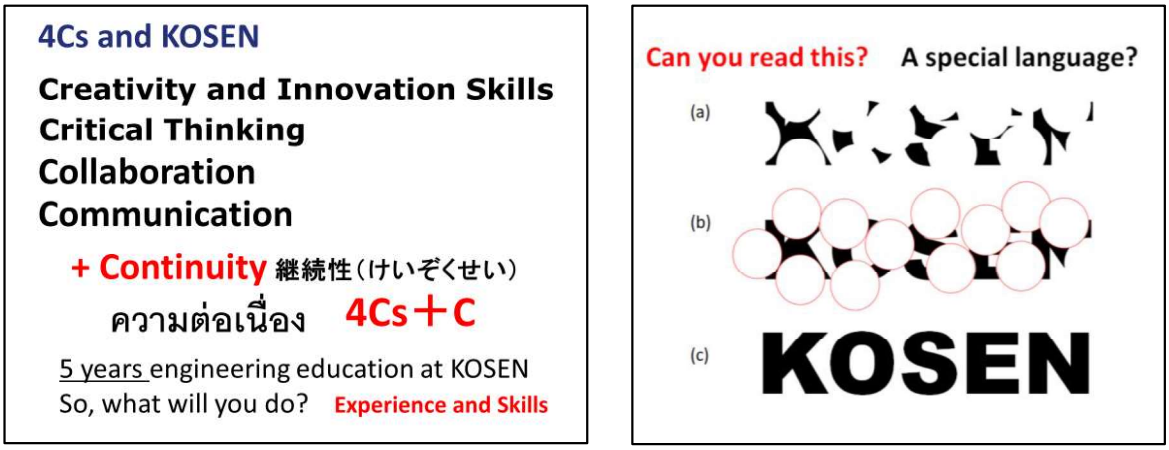

Fig. 5 Examples of PowerPoint slide for KOSEN education and Engineering study

The right slide explains "What is KOSEN" and "How we study Engineering" using a cognitive approach (Aburatani 2014). When the letters are concealed with white circles without border, (a) the remaining parts seem to be a random pattern that has no meaning. However, with borders of circles are shown, it can be read as (b) "KOSEN." This effect is an example of our ability to understanding the continuity of existence of objects (i.e., objects permanence) even when they cannot be seen. Unreadable letters "KOSEN" represent their present understanding of Japanese KOSEN and its education. The blotted letters become meaningful when the borders are provided. This process analogically indicates the procedure to understand not only KOSEN education but also Engineering study itself to the students

(Aburatani, 2014). These are examples of our multiple approaches to initiate and to develop KOSEN engineering education in Thailand; It should be noted that cognitive approaches are effective in delivering the message to the students.

Comparison between KOSEN-KMITL and Japanese KOSEN Curriculum

Although MCC is a common educational platform for NIT KOSEN, each NIT KOSEN provides its own distinctive engineering program, which reflects regional characteristics as well as educational assets. Figure 6 shows a comparison between KOSEN-KMITL and a Japanese KOSEN concerning the ratio of major subjects (Kisarazu College, 2019). Mechatronics consists of the integration of Mechanical engineering, Electrical and Electronic (EE) engineering, and Computer engineering (Programming/IT). A "Control Engineering" department similar to the mechatronics is chosen for this comparison since there is no NIT KOSEN department name with "Mechatronics" at present. The selected Kisarazu KOSEN is accredited by JABEE (Rynearson, 2011) and also a member of the CDIO. For the subject comparison, the major subjects are classified into four groups: EE engineering, Mechanical engineering, Programming/IT, and Mechatronics as the integration of the preceding engineering fields.

It is shown that the ratio of these subjects is reasonably similar to each other, expect the EE engineering and the mechatronics. This difference is due to the nature of mechatronics in which the electrical and electronic engineering plays an important part. A major difference is found for Lab work, project work, and the general engineering mentioned above. KOSEN-KMITL curriculum emphasizes to provide the students with contextualized opportunities to practice independently and build their knowledge through project work and the research work.

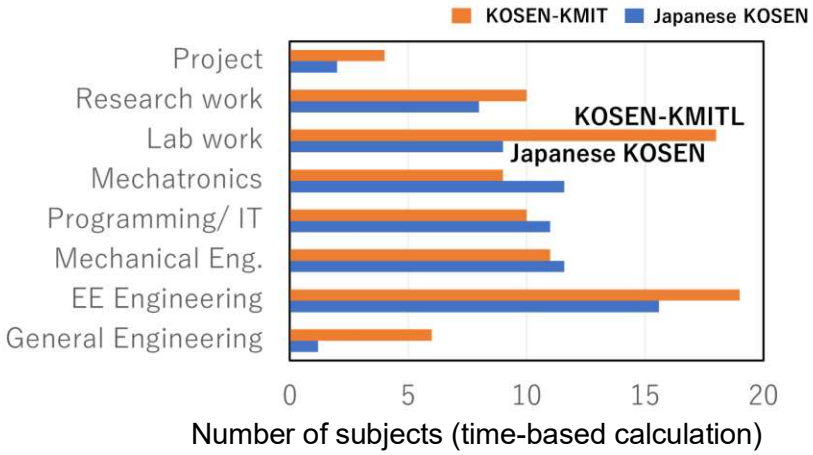

Fig. 6 A subject comparison between KOSEN-KMITL and a Japanese KOSEN

Figure 7 shows a part of the curriculum map related to the lab/project and research work. There are four project-based learning (PBL) subjects through the 3rd to 4th-year grades in conjunction with social study subjects executed in parallel. Topics for the project will be chosen to solve social problems. Especially, UN's Sustainable Development Goals (SDGs) have been included in the curriculum, and the students have started SDGs study from the 1st year. The sequential cycle of learning through the social study and project work towards the final year research/project will provide contextualized learning and encourage student empowerment as well as implement C-D-I-O cycle.

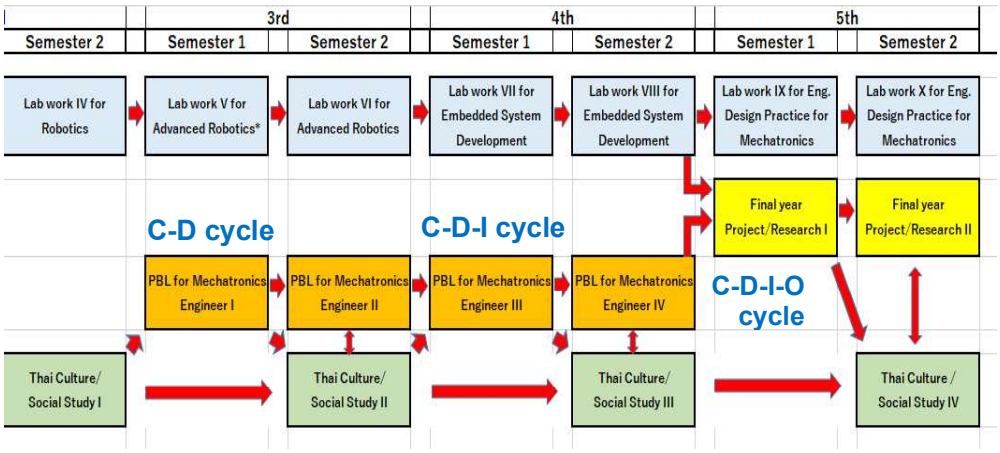

Fig. 7 A part of the curriculum map related to project work and social study

KOSEN Extracurricular Activities and International collaboration

Since KOSEN-KMITL is a newly opened school in collaboration with 51 NIT's KOSEN colleges, many educational challenges are being planned to promote KOSEN education in Thailand. Extracurricular activities within and outside school play very important roles in KOSEN education. Especially, an annually held robot contest known as "KOSEN RoboCon" with approximately 30 years of history and a programming contest (PROCON) among KOSEN colleges are very popular in Japan and attract many prospective students. KOSEN-KMITL is preparing to join these Japanese KOSEN events in the future. Instead of these events, selected four students have already joined KOSEN events in Japan: a Robot festival and a presentation contest. Also, seven student groups attended a robot contest held in Bangkok last year and one group won a prize. KOSEN-KMITL continuously supports and encourages the students to challenge many things to foster their creativity and skills as an important part of KOSEN engineering education.

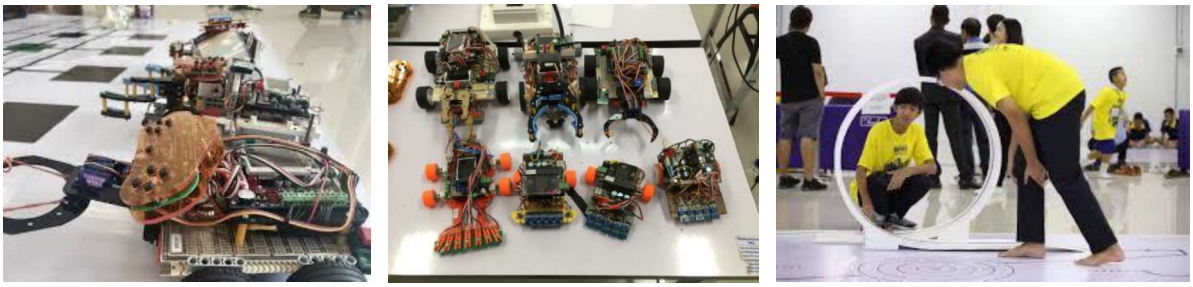

Fig. 8 Pictures of robots for a robot contest held in Bangkok 2019: World Roboto Games

CONCLUSION

In this paper, the engineering education at the Mechatronics department of KOSEN-KMITL, including extracurricular activities and international collaboration between KOSEN-KMITL and NIT KOSEN, is reported. Since KOSEN-KMITL is newly opened KOSEN outside Japan based on NIT's MCC and engineering education concept, many educational challenges are being implemented. It is shown that, as a newly established school without senior students,

introductory subjects play a significant role in fostering the school's identity and young students' mindset as KOSEN students as well as for the engineering.

The curriculum reflecting its uniqueness is compared to NIT KOSEN's one and the CDIO Standard and Syllabus. It is shown that the KOSEN-KMITL curriculum and education well match with the items and the scope of CDIO. The curriculum is designed to promote practical "Monozukuri" education and C-D-I-O process through project-based learning and the research work. From these results, it is shown that KOSEN-KMITL provides the students with Japanese NIT KOSEN quality engineering education as well as the program satisfying the CDIO concepts. It is expected that educational challenges at KOSEN-KMITL will promote further development of engineering education in Thailand to foster the innovative engineers for the future.

ACKNOWLEDGMENTS

The authors would like to thank all Thai parties and Japanese parties that have supported KOSEN-KMITL and its implementation of KOSEN education in Thailand.

REFERENCES

Aburatani, H. (2019). Comparison Between NIT KOSEN Curriculum and CDIO Standards and Syllabus (2019, December 1) Retrieved from http://www.cdio.org/knowledge-library/documents/comparison-between-nit-kosen-curriculum-and-CDIO Standards and Syllabus

Aburatani. H. (2014). Development of Teaching Material to Show Understanding Process- Approach from the Viewpoint of the Mental Process to Show Understanding Process – (in Japanese) (2019 December 1) Retrieved from https://doi.org/10.20549/jseeja.2014.0_328

Cloutier, G., Hugo, R. & Sellens, R (2010). MAPPING THE RELATIONSHIP BETWEEN THE CDIO SYLLABUS AND THE 2008 CEAB GRADUATE ATTRIBUTES*, Proceedings of the 6th International CDIO Conference*, École Polytechnique. (2019, December 1) Retrieved from: http://www.cdio.org/files/document/file/b4-cloutier2011ceabcanada.pdf

The CDIO Initiative. (2019a, November 1).The CDIO Syllabus v2.0 An Updated Statement of Goals for Engineering Education, retrieved from: http://www.cdio.org/files/project/file/cdio_syllabus_v2.pdf

The CDIO Initiative. (2019b, November 1).The CDIO Standards 2.0 retrieved from: http://www.cdio.org/implementing-cdio/standards/12-cdio-standards

Kisarazu College, National Institute of Technology. (2019, December 1) Educational Program for Control engineering department, retrieved from: http://www.kisarazu.ac.jp/wp-content/uploads/2019/04/479ffbdca6f1926bb1611698c68a33bd.pdf

Malmqvist, J (2009). A Comparison of The and EUR-ACE Quality Assurance Systems, *5th International CDIO Conference,* Singapore Polytechnic, Singapore. (2019, December 1) Retrieved from: http://www.cdio.org/files/document/file/D3.1.pdf

National Institute of Technology. (2019, April 1). Model Core Curriculum for NIT Kosen (in Japanese), retrieved from NIT Website: https://www.kosen-k.go.jp/Portals/0/MCC/mcc2017all.pdf

Rynearson, A. (2011). CDIO and Accreditation in Japan. (2019, December 1) Retrieved from: http://www.cdio.org/knowledge-library/documents/cdio-and-accreditation-japan

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