COMPARISON BETWEEN NIT KOSEN CURRICULUM AND CDIO STANDARDS AND SYLLABUS

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ABSTRACT

Japanese College of Technology (known as “KOSEN”) for engineering education, starting at the age of 15, is a Japan’s original tertiary education school established during rapid economic growth in the 1960s. At present, there are 51 national KOSEN colleges operated under the National Institute of Technology (NIT), 3 prefectural/municipal colleges, and 3 private colleges. The KOSEN’s consistent 5-year college engineering education and additional 2-year advanced course education (5+2 = 7 years) including academic research work enables the students to be practical engineers, effectively. Although KOSEN’s curricula have provided sufficient learning opportunity for the students to study theoretical knowledge and to conduct scientific/engineering experiments and workshop training as well as research work to foster practical manufacturing skills of students, KOSEN education also faces various challenges in the globalized world. In order to improve the preparation of KOSEN students to meet high demands in a rapidly changing world, NIT has to improve the curriculum as well as educational approaches. Since AY2018, NIT has implemented an innovative curriculum called “Model Core Curriculum (MCC)” that provides a framework for teaching, learning contents and outcomes levels in major engineering fields as a minimum standard for NIT’s KOSEN. In addition to professional skills, generic skills are also defined as one of the most important outcomes of teaching and learning through the MCC.

In this research, NIT’s MCC is compared to the CDIO standard and syllabus to clarify the similarity and difference between NIT’s KOSEN education and the CDIO initiative. It is shown that the MCC well covers and matches with most of the items in CDIO standard and syllabus. This is due to that KOSEN education focuses on “Monodzukuri” and research work that require engineering design approach and C-D-I-O process. The details of the comparison between NIT’s KOSEN MCC and CDIO, including mapping of criteria and subjects according to educational outcomes and standards and how the MCC works in NIT’s KOSEN education are presented.

KEYWORDS

Active Learning, Assessment, Continuous Improvement of Education, Curriculum Design, Model Core Curriculum, Quality Assurance, CDIO Standards, CDIO Syllabus, CDIO Standards: 2, 3, 5

INTRODUCTION OF KOSEN EDUCATION

KOSEN Education

In Japan, about 1 percent of the upper secondary school graduates enter the College of Technology. College of Technology, Koto-senmon-gakko in Japanese, is also known as its abbreviated name “KOSEN”. KOSEN is Japan’s original tertiary engineering education school starting at the age of 15. KOSEN was first founded to meet the strong demand from industry for practical engineers in 1962 during rapid economic growth in Japan. At present, there are 57 KOSEN in Japan: 51 national KOSEN run by the National Institute of Technology (NIT), 3 prefectural/municipal KOSENs and 3 private KOSENs. Most of the KOSENs provide engineering education programs for associate degrees including Mechanical Engineering, Electrical and Electronics Engineering, Architecture, Civil and Environmental Engineering, Control and System Engineering, Information and Telecommunication Engineering, Chemistry and Biochemistry, Material Science, and Shipping Technology. Students who graduated lower secondary school can apply to KOSEN.

As lower secondary graduates enter KOSEN and KOSEN education is a 5-year college school (five and a half years at colleges of maritime technology), the curriculum is often misunderstood as a combination of upper secondary education with junior college one. 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 evaluated by the public, by industries, and by other institutions. The following comment by an OECD director is a good example describing KOSEN education: “What makes the KOSEN schools different is their unique blend of classroom-based and hands-on, project-based learning.” Figure 1 shows the basic curriculum structure of the 5-year regular course of KOSEN. KOSEN provides the students with a well-balanced General Education subjects (Liberal arts) and Major Engineering subjects in accordance with students' development.

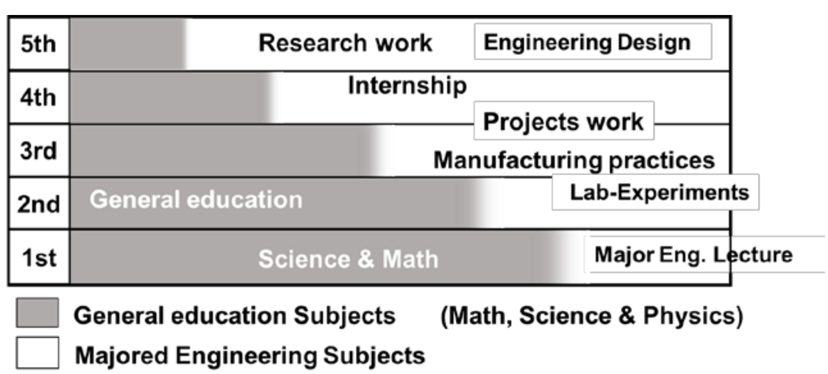

Figure 1. Curriculum structure of the 5-year regular course of KOSEN

As mentioned above, the outstanding characteristic of KOSEN education is its 5 years (regular course as college part) of consistent early engineering education starting from age of 15 years of which the students are usually in the middle of secondary education. With the additional 2-year advanced course education within KOSEN, up to 7 years of consistent engineering education can be conducted through various methods. At present, there are 51 NIT KOSEN (55 campuses), and approximately 50,000 students from age of 15 to 22 years are enrolled. As KOSENs were established to respond to a strong need for well-trained manpower in the rapidly growing industrial/manufacturing sectors, each KOSEN locates basically in industrial city/zone in Japan. About 60 percent of students obtain employment upon their graduation, about 25 percent of the KOSEN graduates proceed to universities and 15 percent of KOSEN students continue their studies and research at two years of advanced courses within KOSEN to obtain a Bachelor's degree. KOSEN education has been playing very important roles in human resource development for industries/manufacturing sectors. In fact, 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 shows a summary of NIT KOSEN.

Table 1 Summary of NIT KOSEN

	Description	remarks
Number of NIT KOSEN	51 Colleges (55 Campuses)	
Admission requirement	Completion of lower secondary education	*
Transferred student	Upper secondary school graduates to the 4th year grade	
Degree to be obtained	5-year regular course: Associate degree	
	2-year advanced course: Bachelor degree	
Number of Students	48,640 (5-year regular course), 2,946 (Advanced course)	As of 2017

* 99.8 percent of those who enter KOSEN Colleges is new graduates from lower secondary schools. In general, mature-aged and post-school entry is not popular in Japan.

Model Core Curriculum

Over fifty years have passed since the first KOSENS were established and the social demands for KOSEN education as well as engineers have changed. As mentioned in the CDIO syllabus, modern engineering education programs need to foster the students' broad base of knowledge, skills, and attitudes necessary to become successful and innovative engineers. In order to improve the preparation of KOSEN students to meet these high demands in a rapidly changing world and technology, NIT has designed "Model Core Curriculum (MCC)." MCC was designed in reference to international standards, such as the criteria of Accreditation Board for Engineering and Technology (ABET), Standards for the Accreditation of Engineer Education by JABEE (Japan Accreditation Board for Engineering Education), UK Quality Assurance Agency for Higher Education (QAA) as well as the CDIO syllabus. MCC provides a framework for learning contents and outcome levels as a minimum standard for NIT KOSEN. Table 2 shows the contents of MCC.

Table 2. The Contents of Model Core Curriculum

Chapter	Contents
1	Educational Modalities Based on Model Core Curriculum
2	Attainment Targets for Basic Competency Requirements for Engineers
3	Attainment Targets for Knowledge, Expertise and Competency Requirements for Engineers
4	Attainment Targets for Interdisciplinary Competency Requirements for Engineers
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 among teachers on educational contents and teaching methods

5.4	Systematic Implementation of FD/SD
5.5	Mechanisms for Students' Self-Oriented Learning with reflecting their achievements
5.6	Developing the mechanisms for evaluation and continuous improvement of the Model Core Curriculum

Chapter 1 gives an introduction and rationale of MCC. From Chapter 2 to 4, various competency and desired attainment levels for engineers are described. Chapter 5 covers Quality Assurance. Although all chapters contain sub-chapters, only those of Chapter 5 is listed for the comparison between MCC and CDIO standards shown afterwards. The general education including STEM covered by MCC is listed in Table 3. In the MCC, competencies required as engineers are broadly divided into three categories as described in Table 3 to Table 5 according to major engineering fields and students' career paths. These three categories, namely "Basic Competency requirements engineers (I to IV)" in all areas, "Knowledge, Expertise and Competency requirements for engineers (V to VI)" and "Interdisciplinary Competency requirements for engineers (VII to IX)."

Table 3. Basic Competency requirements engineers: General education including STEM

I. Mathematics	
II. Natural Science	II-A Physics II-B Physics Laboratory II-C Chemistry II-D Chemistry Laboratory II-E Life Science and Earth Science
III. Humanities and Social Sciences	III-A Japanese III-B English III-C Social Studies
IV. Basic Engineering	IV-A Engineering experiment techniques (measuring methods, data processing methods and analytical approaches) IV-B Ethics for engineers (including intellectual property, legal compliance and sustainability) and Engineering History IV-C Information Literacy IV-D Globalization and Multicultural Studies

Table 4. Knowledge, Expertise and Competency requirements for engineers: Major fields

V. Knowledge and Expertise for each Engineering	V-A Mechanical Engineering V-B Material Engineering V-C Electrical & Electronic Engineering V-D Information Technology V-E Biological & Chemical Engineering V-F Civil Engineering V-G Architecture V-H Maritime Engineering (Navigation) V-I Maritime Engineering (Ship Engineering)
VI Engineering Experiments and Practice Competencies	VI-A Mechanical Engineering VI-B Material Engineering VI-C Electrical & Electronic Engineering VI-D Information Technology VI-E Biological & Chemical Engineering

	VI-F Civil Engineering VI-G Architecture VI-H Maritime Engineering (Navigation) VI-I Maritime Engineering (Ship Engineering)

Table 5. Interdisciplinary Competency requirements for engineers

VII General Skills	VII-A Communication Skills VII-B Consensus-building Skills VII-C Skills to gather, effectively use & communicate information VII-D Identifying Problems VII-E Logical Thinking
VIII Mindset and Direction (Personality)	VIII-A Sense of Self-ownership VIII-B Self-management Ability VIII-C Sense of Responsibility VIII-D Teamwork Skills VIII-E Leadership VIII-F Sense of ethics for engineers (respect for creativity and public morality) VIII-G Future-oriented vision and career designing ability VIII-H Comprehension of corporate activities VIII-I Comprehension of relationship between study and corporate activities
IX Integrated Learning Experience and Creative Thinking	IX-A Creative Innovation Ability IX-B Engineering Design Ability

In the MCC, the attainment targets of each subject are determined based on 6-level Bloom's Taxonomy. Table 6 shows the relationship between the attainment target levels and the corresponding education programs (fields).

Table 6. Attainment levels of KOSEN 5-year regular curse and 2-year advanced course.

Competency Requirements	Attainment Levels					
	1	2	3	4	5	6
	Know/Re-member	Understand	Apply	Analyse	Evaluate	Create
Basic Competency Requirements for Engineers						
I. Mathematics	K	K	K	A	S	S
II. Natural Science	K	K	K	A	S	S
III. Social Sciences	K	K	K	A	S	S
IV. Basic Engineering	K	K	K	A	S	S
Knowledge, Expertise and Competency requirements for engineers						
V. Knowledge and Expertise for each Engineering	K	K	K	K	A	S
VI. Engineering Experiments and Practice Competencies	K	K	K	K	A	S
Interdisciplinary Competency requirements for engineers						
VII. General Skills	K	K	K	A	S	S
VIII. Mindset and Personality	K	K	K	A	S	S
IX. Integrated Learning Experience and Creative Thinking	K	K	K	A	S	S

Note: K: KOSEN regular (College) course, A: Advanced course, and S: Higher-level qualification such as professional engineer

These listed learning contents and competency with attainment targets as well as 5-year long plan for students' educational achievement ensure the quality of engineering education at NIT KOSEN.

Since the academic year 2018, all NIT KOSENs' syllabus based on MCC is listed and shared on the KOSEN website (https://syllabus.kosen-k.go.jp/Pages/PublicSchools, in Japanese). All subjects at NIT KOSENs will be correlated to MCC and be managed to accomplish all educational goals in MCC. Figure 2 shows the implementation status of MCC for subjects provided in AY2018. Although some NIT KOSENs have reported lower implementation of MCC correlated subject (>50%) due to characteristics of department/program or ongoing programs, it is shown that about 43 % of NIT KOSENs have fully adopted MCC (100%) and 90 % adoption for another 43 % of NIT KOSENs, respectively.

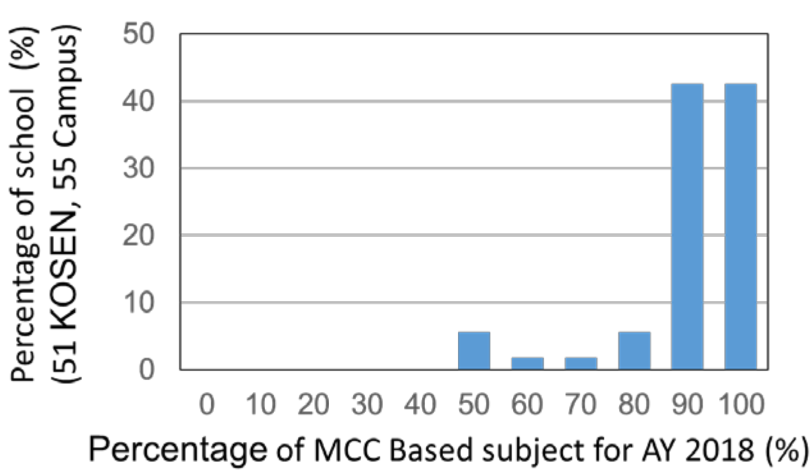

Figure 2. Implementation status of MCC for subjects provided in AY2018

It should be noted that each NIT KOSEN has been planning and implementing its own distinctive education in addition to MCC, since MCC covers only the core part of curriculum contents (60-70%). Original educational programs reflecting regional characteristics as well as educational assets provide the students with contextualized learning opportunities. NIT's "KOSEN 4.0 Initiative" is an educational project to promote distinctive educational programs at each KOSEN, especially for "Human resource development for new industries", "Contribution to regional development," and "Globalization" of NIT KOSEN education. For the last two years, 71 unique programs have been adopted and implemented. (https://www.kosen-k.go.jp/about/profile/main_super_kosen_4.0list.html, in Japanese)

COMPARISON BETWEEN NIT MCC AND CDIO

MCC and CDIO syllabus

In the MCC, education programs with learning contents and goals are described in Chapter 2 to 4 which is corresponding Table 3 to 5 in this paper: "Basic Competency requirements engineers (I to IV)", "Knowledge, Expertise and Competency requirements for engineers (V to VI)" and "Interdisciplinary Competency requirements for engineers (VII to IX)." Table 7 shows the correlation mapping between these items (I to IX) to the CDIO syllabus (Malmqvist 2009), (Cloutier, Hugo & Sellens 2010). It is shown that MCC items are strongly correlated to CDIO syllabus items, except 4.2, because entrepreneurship that is also described in the extended CDIO syllabus is not covered by MCC.

The uniqueness of the KOSEN curriculum is a blend of classroom-based, hands-on, project-based learning, as well as "Research Work". The number of credits for research work is typically about 10 credits at the 5th year grade as a culmination of study in KOSEN. As a culture of KOSEN education, the topics of their research have tended to be academic ones and the results have been reported at academic societies and conferences. Thus, KOSEN education has mostly focused on scientific and technological interest as "Monozukuri", but less interest in business and operation of a business. However, entrepreneur education has been adopted in NIT KOSEN education as extra-curricular activities (e.g. Startup contest, Hackathon, etc.). Therefore, the part of entrepreneurship belongs to each KOSEN's education program.

Regarding the concept of "Conceive", "Design", "Implement", and "Operate," NIT KOSENs provide the students with subjects/programs such as Research work, Project Based Learning, etc. based on "Engineering Design" concept that is also adopted by JABEE. Especially, the research work at the 5th 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 in the program. With regard to JABEE, 95 % of NIT KOSENs have been accredited by JABEE and 41 NIT KOSEN programs are JABEE accredited at present. Although some NIT KOSENs have voluntarily withdrawn from JABEE to seek their own characteristic educational programs, most of NIT KOSEN's engineering education programs are found to match with JABEE's criteria. As JABEE criteria are reported to correlate well with the CDIO syllabus (Rynearson 2011), it seems that NIT KOSEN's engineering education is highly consistent with CDIO standards.

Table 7. Correlation of NIT KOSEN MCC to CDIO Syllabus

CDIO Syllabus	NIT KOSEN Model Core Curriculum								
	I	II	III	IV	V	VI	VII	VIII	IX

1	1.1	●	●							
	1.2				●					
	1.3					●	●			
2	2.1							●		●
	2.2						●	●		●
	2.3						○	●		●
	2.4								●	
	2.5							●	●	
3	3.1							●	●	
	3.2							●		
	3.3			●	●					
4	4.1			●	●					●
	4.2			○					○	
	4.3						○			●
	4.4						○			●
	4.5						○			●
	4.6						○			●

○: Weak correlation ●: Strong correlation

MCC and CDIO standards

All MCC contents, Chapters 1 to 5, are compared with CDIO standards as shown in Table 8. Since MCC encompasses learning contents for each engineering field with specific attainment target levels, students' professional and generic competencies, curriculum design, educational approaches, quality assurance measures, etc., it correlates well with CDIO Standards. Especially for "9. Enhancement of Faculty Competence", NIT HQ has planned and conducted various workshops and training for KOSEN faculties based on MCC in addition to each KOSEN's faculty training. From these results, it is shown that NIT KOSEN's education programs based on MCC highly match with both the CDIO syllabus and standards.

Table 8. Correlation of NIT KOSEN MCC to CDIO Standards

CDIO Standards	Model Core Curriculum				
	C. 1	C. 2	C. 3	C. 4	C. 5
1: The Context	○	○	○	○	●
2: Learning Outcomes		●	●	●	
3: Integrated Curriculum			●	●	●
4: Introduction to Engineering		●			
5: Design-Implement Experiences			●	●	
6: Engineering Workspace			●		

7: Integrated Learning Experiences		○	○	●	
8: Active Learning				●	●
9: Enhancement of Faculty Competence					●
10: Enhancement of Faculty Teaching Competence					●
11: Learning Assessment*		○	○	○	●
12: Program Evaluation					●

○ : Weak correlation ●: Strong correlation

CONCLUSION

This paper provides a comparison between the NIT KOSEN Model Core Curriculum (MCC) and CDIO Standards and Syllabus. As the MCC covers learning contents for each engineering field with specific attainment target levels, students' professional and generic competencies, curriculum design, educational approaches, quality assurance measures, etc., it correlates well with the CDIO Standards and Syllabus, except entrepreneurship part (i.e., Syllabus 4.2).

Regarding the concept of C-D-I-O, NIT KOSENs provide the students with programs (e.g. Research work, Project Based Learning) based on "Engineering Design" concept which is also consistent with the CDIO concept. From these results, it is revealed that NIT KOSENs share the same educational views with the CDIO initiative. In fact, 5 NIT KOSENs have joined the CDIO initiative so far (last 3 years). Nowadays, it is important for all engineering education institutes to develop students' broad base of knowledge, skills, attitudes and competencies across the curriculum/program for their future success as engineers. Therefore, it is expected that joining of NIT KOSEN's joining to CDIO initiative will promote sharing NIT KOSEN's educational experience and practice with CDIO initiative and member institutes as well as further development of engineering education program.

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