ADVANCING CDIO CURRICULUM MODEL FOR THAI ENGINEERING AND NON-ENGINEERING PROGRAMMES

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ABSTRACT

Rajamangala University of Technology Thanyaburi (RMUTT), Thailand has adopted a thematic approach to Advancing CDIO Curriculum Development comprising Mapping – Enhancing – Innovating – Sustaining in collaboration with Singapore Polytechnic, Singapore. This paper focuses on mapping and enhancing approaches to curriculum design and development first to occur. In 2018, RMUTT launched a policy at the institutional level for curriculum development for a total of 34 programs comprising 6 engineering and 28 non-engineering programmes. CDIO workshop was conducted for 200 program committees from 7 faculties to prepare them for reimagining the curriculum redesign. For the mapping approach, a trend analysis was conducted to identify future-ready competencies and future graduate attributes and correspondingly develop relevant programme outcomes. For the enhancing approach, two new mandatory courses, namely, Introduction to the Profession and Multi-disciplinary Project (MDP) courses, were introduced. These two courses were developed in accordance with CDIO standards 4 and 5 by offering a design-build-test learning experience to the students. Other CDIO skillsets such as professional competencies, personal and interpersonal skills are integrated into the program systematically. This paper aims to share similarities and differences of graduate attributes and program outcomes between engineering and non-engineering focus in the Thai industry context. The implementation of mapping and enhancing approaches will also be discussed.

KEYWORDS

curriculum development, mapping CDIO skillsets, enhancing multi-disciplinary project, Standards 1, 2, 3, 4, 5

INTRODUCTION

Major milestones of RMUTT curriculum design and development can be grouped into 3 phases. Phase one was from 2013-2015 when Conceive, Design, Implement, and Operate (CDIO) Framework was first introduced for rethinking engineering education. Only 2 programmes had fully implemented at the program-level in 2013, namely, Industrial Engineering and Chemical Textile Engineering (Kuptasthien et al., 2014). In 2014, 6 non-engineering programmes from the faculty of Mass Communication Technology adopted the CDIO framework. These programs were Television & Radio, Photo & Cinematography, Printing Technology, Multimedia, Digital Media and Advertisement, and Public Relations (Tangkijviwat et al., 2018). In 2015, Thai Traditional Medicine College applied the CDIO framework to 2 programs; namely, Applied Thai Traditional Medicine and Health & Aesthetic (Sranujit and Kuptasthien, 2016).

The second phase was from 2016-2017 when RMUTT embraced a thematic approach to Advancing CDIO Curriculum Development comprising Mapping – Enhancing – Innovating – Sustaining in collaboration with Singapore Polytechnic (SP) (Lee et al., 2018). There were 5 programs that participated in redesigning future-focused curriculum comprising of Industrial Engineering, Multimedia, Hotel & Tourism Management, Innovation of Health Product and Architecture.

The third phase was from 2018-2019, when RMUTT launched a policy at the institutional level on curriculum development for a total of 34 programs comprising 6 engineering and 28 non-engineering programs. CDIO workshop was conducted for 200 program committees from 7 faculties to prepare them for curriculum redesign (Sripakagorn and Kuptasthien, 2019).

This paper aims to:

1) Show how mapping and enhancing approaches were implemented.
2) Share the similarities and differences of graduate attributes and program outcomes between engineering and non-engineering focus in the Thai industry context.
3) Discuss the result.

LITERATURE REVIEW ON CURRICULUM DESIGN

The key characteristics that CDIO is attractive to institutions worldwide are relative advantages, compatibility, simplicity, trial-ability, and observability (Kontio, 2017). Reasons for implementing the CDIO framework included (1) ambitions to make engineering education more authentic (2) needs for a systematic methodology for educational design and (3) desires for more design and innovation in curricula (Malmqvist et al. 2015). The success of CDIO implementation needs both top-down and bottom-up approaches. The top-down methodology can be a decision for the management team to adopt the CDIO framework regarding the compatibility of the institutional vision on education development goals. However, the challenges of CDIO implementation are a mindset change, a buy-in from faculty members, disagreement, and a double work regarding the national qualification standards and accreditation. To overcome these challenges, the bottom-up method is suggested (Lee et al., 2015). With the involvement of faculty members, program committees, and department heads, the changing process raises an intrinsic motivation, a strong commitment, ownership, and value of CDIO (Hallenga-Brink and Kok, 2016).

CDIO Syllabus and CDIO Standard are guidelines for curriculum design and development. Several leading universities have created their own models, methodologies, a process in executing the plan to redesign the existing curriculum or design and develop a new one.

Linköping University (LiP), one of the CDIO pioneers, early implemented CDIO into their Applied Physics and Electrical Engineering, Electrical Systems Engineering, Media and Communication Technology, and Logistics Engineering programs. The stakeholders involved include the faculty, the industry, and the students. The development of programs covered three main areas of a survey on the CDIO syllabus, an introduction of LIPS models for design-build project management, and final approval of CDIO ideas with a strong focus on the graduates to become professional engineers (Bjerner and Granath, 2005).

At the Technical University of Denmark (DTU), the decision on CDIO adaptation was made by the management team. A benchmarking process of the existing Chemistry and Biotechnology program was performed to identify where CDIO elements were already present, and where the rooms for improvement were. For CDIO Syllabus benchmarking, a color mapping scheme with the integration of modified Bloom's Taxonomy and the introduce-teach-use ranking was suggested to gain the competence matrix interpretation (Vigild et al., 2007).

Later on, Gunnarsson et al. (2008) showed a comparison on a large scale implementation using CDIO Syllabus to formulate program goals and learning outcomes between LiP and DTU. The work exhibited processes and tools for educational program design, including local CDIO Syllabus adaptations to meet national higher education regulations, an introduce-teach-use (ITU), and skill progression matrices.

Armstrong and Niewoehner (2008) proposed an enhanced CDIO methodology to develop the student's skills and attributes required for professional engineers. To define program learning outcomes, a methodology encompassed a customised syllabus, a stakeholder's survey, an application of Bloom's Taxonomy, a consultation with accreditation criteria. The integrated curriculum can be planned with considerations of program learning outcomes, disciplinary learning outcomes, an existing curriculum benchmark with ITU, measurable attributes, a skills development plan, and CDIO standards.

A curricular reform with the CDIO framework at Shantou University, China, was based on an integrated, holistic approach to addressing the changing industrial demands. A design-directed structure was used to redesign 5 engineering programs with a special focus on Ethics, Integrity, and Professionalism, resulting in an EIP-CDIO initiative at the institution (Gu et al., 2007).

Popp and Levy (2010) published a method for mapping the curricula against any generic framework based on the CDIO syllabus and the Engineers Australia National Generic Competency Standards. The new methodology resulted in the ease of mapping and the reduction of the redundancy of the academic inputs.

Hellinga-Brink and Kok (2016) managed a CDIO implementation for 12 programs by track categorisation. The fast track was for the program that already implemented CDIO, the drawing board was for the program that needs to redesign the curriculum, and the quality track for the program that used CDIO for a quality improvement tool.

The key success factors for CDIO implementation at Singapore Polytechnic (SP) include support from management, a close collaboration of drivers, a customised CDIO syllabus by early adopters and education specialists, and CDIO standards interpretation for the local context. As an Asian regional leader, SP provides expertise to assist faculty in implementing the CDIO framework with SP 5-component model; namely, Introduction to CDIO Teaching and Learning Framework (Standard 1), Designing an Integrated Curriculum (Standards 2, 3, 7 and 11), Conceiving and Designing Innovative Products and Systems (Standards 4, 5 and 6), Designing Active and Experiential Learning Experiences to enhance students learning (Standard 8), and Programme evaluation to evaluate the impact of CDIO implementation (Standard 12) (Lee et al., 2015).

Expanding from engineering education, the CDIO framework shows a promising result with non-engineering implementation. Doan et al. (2014) developed Generalized CDIO standards to be utilized, along with suggestions from Crawley (2014). The non-engineering programs CDIO adaptation embraces the development of professional context, close work with stakeholders, disciplinary pedagogical development, and program evaluation. Malmqvist et al. (2016) exhibit applications of CDIO for non-engineering programs in Finland, Singapore, and Vietnam. The benefits of implementing CDIO were a better connection to working life practice, strong links between program development and quality assurance, and improvement of educational quality and an increase of design and innovation skills.

CDIO initiative has reached the 20-year milestone in 2020, new waves of challenges emerged rapidly with industry 4.0 and new sets of industrial demands. A thematic approach based on the core principles of Future-Focused, Purpose-Driven, Design-Led, and Quality-Minded educational development will ensure the success of higher education institutions. SP's Advancing CDIO curriculum development approach comprises 4 themes: Mapping; Enhancing; Innovating, and sustaining (Lee et al., 2018). This paper will elaborate more on the Mapping and Enhancing phases.

METHODOLOGY

RMUTT embraces the vision to be an "Innovative University" with the launch of policy at the institutional level for curriculum development. Thirty-four bachelor programs (6 engineering and 28 non-engineering) needed to be redesigned and aligned to the new vision. A 2-day workshop was conducted for 200 program committees from 7 faculties to prepare them for the curriculum redesign. CDIO master trainers acted as facilitators during the working process. They shared their experiences as CDIO practitioners on their own program, as well as encouraging discussions among the participants.

With an intention to conform to the Thai Qualification Framework (TQF), series of blank templates and documentation were planned ahead. The Mapping process covered a STEEP (Social, Technological, Economical, Environmental, and Political) analysis, a stakeholder survey, a skillset mapping, and an identification of new competencies, graduate attributes, program learning outcomes, and future careers. Fig. 1 shows the mapping process.

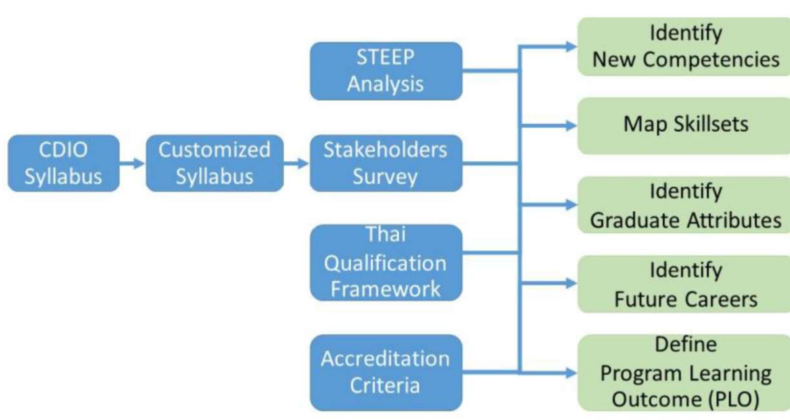

Figure 1. A mapping process

Stakeholders Survey

The CDIO Syllabus was customized to fit the context of RMUTT. A general questionnaire survey was designed by the CDIO master trainers and distributed to the program committee 2 months prior to the curriculum development workshop. The program committee may customise the questionnaire to match with their professional context—a stakeholder survey comprised of surveys from industry, alumni, and current students. The data were analysed prior to the workshop.

STEEP Trends Analysis

STEEP Analysis is a common tool for evaluating different external factors that have an impact on an organization (PESTLE analysis, 2015). This tool allowed the program committee to explore future trends and their implications and helped to predict what might happen in the future. Five categories in the STEEP analysis are Social & Demographic, Technology, Economic, Environment & Nature, and Political & Legal.

Thai Qualification Framework (TQF)

Thai curriculum is required to cover the 5 or 6 following learning domains (OHEC, 2010): Domain 1: Ethical and moral development, Domain 2: Knowledge, Domain 3: Intellectual, Domain 4: Interpersonal skills and responsibility, Domain 5: Analytical, communication and information technology (IT) skills, and Domain 6: Practical Skills. Different curriculum may have different sub-domains. Kuptasthien et al. (2018) identified CDIO-TQF mapping and their linkages. By implementing the CDIO framework, the TQF learning outcomes are also fulfilled.

Accreditation Criteria

The accreditation criteria were carefully considered during the redesign of the program. Therefore, the redesigned curriculum could also be accredited.

Identify New Competencies

Referencing the impacts of the future trends and future of work, the program committee identify new or emerging competencies the student should possess to be ready for the future reality.

Identify Future Graduate Attributes

Insights on the future reality assist the program committee to identify what are the desired future graduate attributes, which include knowledge, skills, mindset, and attitudes.

Mapping Skillsets

Graduate competencies and attributes were mapped with the CDIO Syllabus in order to determine which CDIO skillsets to strengthen and integrate into the program curriculum.

Identify Future Careers

With results from the stakeholder survey, new competencies, and future trends analysis, the program committee identify aspects of future career opportunities for the graduate.

Define Program Learning Outcome

The last step of the mapping process was to define the program learning outcome. Information obtained from all steps were then documented in the program curriculum file.

The Mapping phase can be viewed as an implementation of CDIO Standards 1 to 3, where the professional context was taken into account, with the involvement of stakeholders, to redesign the curriculum. The next step was the implementation of CDIO Standards 4 and 5. Normally all programs require a senior project as a part of graduation when the student is in the 4th year. With the vision of an Innovative University, a Play-Passion-Purpose concept (Wagner, 2014) was combined with the CDIO Standards 4-5 to portrait a 4-year transition from the freshman to the graduates, as shown in Fig. 2.

For the Enhancing phase, the program committee created 2 new courses, namely, an Introduction to Profession and a Multi-disciplinary Project (MDP) course. These courses provide design-built-test learning experiences to the students. The benefit of having all programs in the workshop together, faculty members from different disciplines can discuss the possibilities of the MDP. Templates were provided with the aim to integrate professional competencies, personal, and interpersonal skills into the courses systematically.

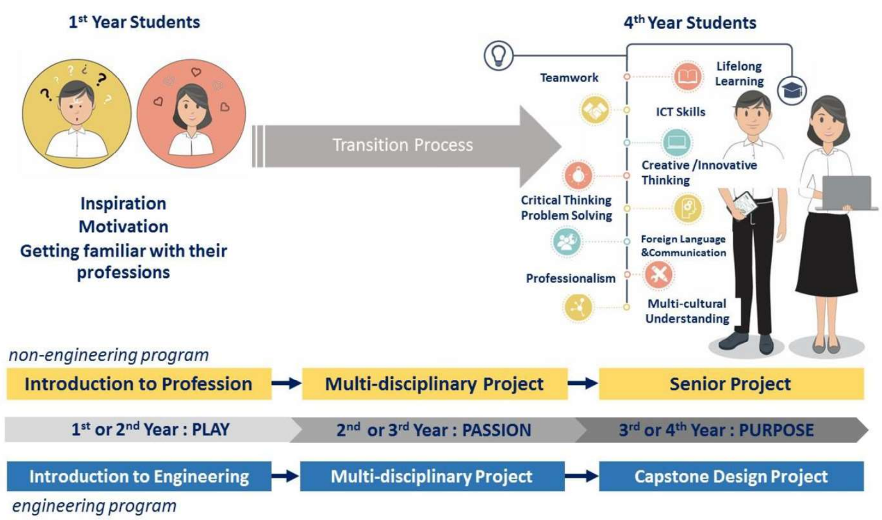

Figure 2. An enhancing process

RESULT AND DISCUSSION

Fig. 3 and Table 1 show graduate attributes from 34 different programs from 7 faculties. There were 28 programs that selected Creative Thinking as one of the graduate attributes, especially all programs in Agricultural Technology (3), Liberal Arts (2), Mass Communication Technology (5), and Fine and Applied Arts (7) faculties. There were 22 programs that chose Teamwork skills and Communications skills. Twenty programs chose System Thinking, especially all 6 engineering programs. All 8 programs in Business Administration faculty selected ICT skills as one of the graduate attributes, the same as the other 11 programs. There were 13 programs that chose Entrepreneurship, 12 programs chose Critical Thinking, and 12 programs chose Designing skills.

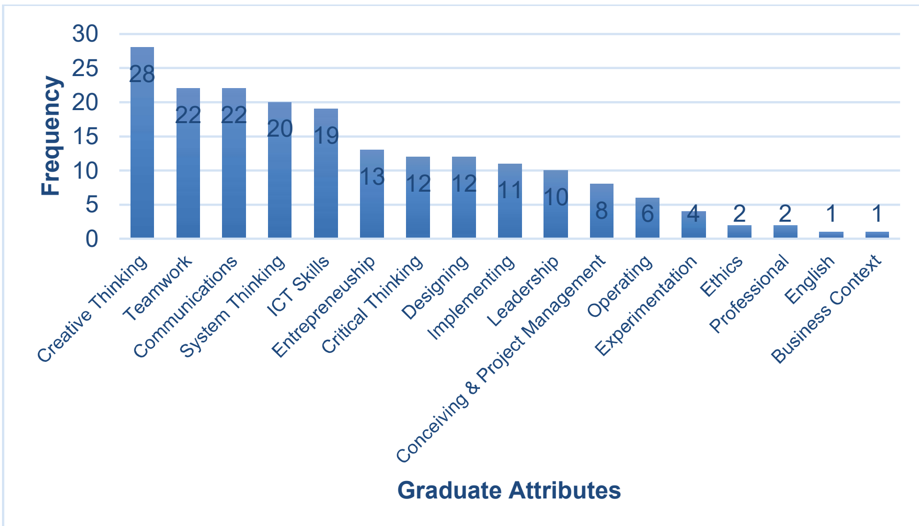

Figure 3. Frequencies of selected graduate attributes from 34 programs

Interestingly, Food Science and Technology and Advertising and Public Relations Technology programs indicated Ethics as one of the graduate attributes, which was further put into their integrated curriculum. Industrial Engineering and Digital Printing and Packaging Technology highlighted Professional skills. Only Food Science and Technology selected the English language. Industrial Engineering program would like to add Business Context in their integrated curriculum as well.

Table 1. Selected Graduate Attributes for 34 Programs at RMUTT

	Graduate Attribute	Analytical Thinking & Problem Solving	Experimentation	System Thinking	Creative Thinking	Critical Thinking	Ethics	Professional	Teamwork	Communications	English	Business Context	Conceiving & Project Management	Designing	Implementing	Operating	Leadership	Entrepreneurship	ICT Skills
Faculty of Agricultural Technology																			
1	Fisheries			●	●					●			●					●	●
2	Food Science and Technology				●		●		●		●				●				●
3	Landscape Technology				●								●	●			●	●	
Faculty of Engineering																			
4	Computer Engineering			●	●								●					●	
5	Industrial Engineering			●		●		●	●	●		●		●	●	●			
6	Electronics and Telecommunication Engineering		●	●	●	●			●	●									
7	Environmental Engineering	●		●	●				●	●				●					
8	Food Engineering		●	●					●	●							●		
9	Textile Chemical and Fiber Engineering	●	●	●	●	●							●		●				
Faculty of Business Administration																			
10	Business English			●	●				●	●			●				●	●	●
11	Computer Business	●		●	●					●			●	●					●
12	Economics				●	●			●	●									●
13	Finance	●		●	●	●				●			●						●
14	International Business	●			●	●			●	●							●	●	●
15	Logistics and Supply Chain Management	●		●		●										●			●
16	Marketing			●	●					●				●	●		●	●	●
17	Management	●		●	●				●	●							●	●	●
Faculty of Home Economics																			
18	Food Industry and Services	●		●						●				●	●		●		●
19	Food and Nutrition	●		●					●							●			●
20	Fashion Design and Clothing				●				●						●			●	
Faculty of Liberal Arts																			
21	Tourism				●	●			●	●				●			●	●	●
22	Hotel Management	●		●	●	●			●	●							●	●	●
Faculty of Mass Communication Technology																			
23	Photography and Cinematography Technology	●		●	●				●	●									●
24	Digital Printing and Packaging Technology	●			●	●		●					●		●	●			
25	Radio and Television Broadcasting Technology				●	●			●	●								●	●
26	Advertising and Public Relations Technology			●	●		●		●	●								●	●
27	Multimedia Technology			●	●				●										●
Faculty of Fine and Applied Arts																			
28	Innovation Contemporary Product Design			●	●									●	●				
29	Interior Design				●				●	●				●					●
30	Music				●				●				●			●			
31	Product Design		●		●									●	●				
32	Sculpture				●				●	●				●	●	●	●	●	
33	Thai Arts				●				●	●				●	●			●	●
34	Visual Communication Design			●	●	●			●	●									

There are some similarities between RMUTT Music and program and SP Music and Audio Technology (Malmqvist et al., 2016). They both need the operating skills or technical learning outcome relating to music and audio competences. Teamwork and Thinking skills were also the same for both programs. However, SP's Music and Audio Technology had oral and written communication skills, while RMUTT's Music program emphasised in Project Management to be added in the curriculum. The similarity could also be seen with the RMUTT Multimedia program, where they highlighted thinking, teamwork, and ICT skills.

The study also found similarities between RMUTT and SP Food Science and Technology programs (Malmqvist et al., 2016). They both underlined Ethics and Responsibility as key attributes, along with Teamwork and Creativity. We found similarities between RMUTT and TUAS in business programs as they focused on training the students in business development, entrepreneurship with ICT skills, as well as and innovative attitude (Malmqvist et al., 2016). RMUTT's business programs have indicated different kinds of thinking skills, including analytical, creative, critical system thinking, along with teamwork and communications.

Table 2 shows the list of examples for the Introductory and MDP courses for different programs resulting from the Enhancing process.

Table 2. List of Examples of Introductory and MDP Courses

Program Name	Introductory Course	MDP (Disciplines)
Food Science and Technology	Introduction to Food Science and Technology	Food Product Development (Food Science, Packaging Design, Business)
Industrial Engineering	Industrial Design and Build	Innovative Product Design and Entrepreneurship (Industrial Engineering, Product Design, Entrepreneurship)
Environmental Engineering	Environmental Unit Operation	Waste Management (Environmental Engineering, Mechanical Engineering, Electrical Engineering)
International Business	Introduction to International Business	Global Business Entrepreneurship in the Digital Era (International Business, Marketing, IT)
Logistics and Supply Chain Management (SCM)	Warehouse Management	Information Technology in Logistics & SCM (Logistics & SCM, IT, Business)
Food and Nutrition	Perspective in Food and Nutrition	Food Innovation Contest (Food and Nutrition, Advertising, Art)
Hotel Management	Introduction to Hotel Management	Thai Food Innovation (Hotel Management, Food Science, Art)
Photography and Cinematography Technology	Media Production for Photography and Cinematography	Theatrical Film Production (Photography and Cinematography, Multimedia, Music Composition)
Digital Printing and Packaging Technology	Printing Technology	Entrepreneurship in Printing and Packaging Business (Printing and Packaging Technology, International Business, Thai Herbal Product Development)
Innovation Contemporary Product Design	Mini Project Innovative Product Design	Innovative Product Design (Product Design, Art, Business)
Visual Communication Design	Mini Project Visual Communication Design	Visual Communication Design (Visual Communication Design, Animation, Business)

CONCLUSION

Both engineering and non-engineering programs at RMUTT successfully adopted CDIO Syllabus and CDIO Standards 1-5 for redesigning their curriculum. The mapping process showed some similarities and differences regarding the disciplinary nature and the future landscape of the industries. With the ultimate goal of producing hands-on graduates in the innovative era, the program learning outcomes were shaped by the mapping progression. In addition, all 34 programs created new courses for the purpose of enhancing their students' knowledge, skills, and attitudes in order to achieve their program outcome.

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BIOGRAPHICAL INFORMATION

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