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Innovative Pedagogy in CDIO Implementation for Engineering Education

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Abstract: *Engineering accreditation council (EAC) and Engineering Technology Accreditation Council (ETAC) requires CDIO initiative to be implemented in engineering programs. In term of delivery, CDIO standards emphasis on integrated learning experiences and active learning. While the reformed curriculum has been developed at macro level, changes impact directly on academics' skills development and delivery to suit 21st century learning environment which are ubiquitous, flexible and technology based. Faculty of Civil Engineering UiTM Pahang (FCE) shared the classroom implementation applying innovative pedagogies to provide students with learning experiences stresses engineering fundamentals that are set in the context of Conceiving – Designing – Implementing – Operating (CDIO). The paper describes the diversity of classroom practices shared by FCE, progress and impact.*

Keywords: *CDIO, Engineering Education, Innovative Pedagogies.*

INTRODUCTION

Curriculum design in engineering education has experienced procedure of transformation to conform requirement in engineering accreditation. Accreditation bodies through Engineering Accreditation Council (EAC) and Engineering Technology Accreditation Council (ETAC) emphasis all undergraduate engineering programs in Malaysia to demonstrate attainment of specific learning outcomes. EAC and ETAC used general description for example 'ability' and 'demonstrate competency' without detailing the level to be achieved (Kamsah and Kassim, 2013). These requirements is detailed and complimented with CDIO framework.

CDIO initiative is an engineering education framework has expanded to

include engineering program worldwide with the project vision to provide students with an education stressing on engineering fundamentals set in the context of Conceiving, Designing, Implementing and Operating (hence the acronym CDIO) real-world system and products (Kamsah and Kassim, 2013, Berggren et al., 2003). Berggren et al., (2003) explained the CDIO initiative strategy divided into four themes; 1) curriculum reform to ensure that students have opportunities to develop the knowledge, skills and attitudes to conceive and design complex systems and products 2) improved level of teaching and learning necessary for deep understanding of technical information and skills 3) experiential learning environments provided by laboratories and workshops 4) Effective assessment methods to determine quality and improve the learning process. CDIO emphasis on integrated learning experiences and active learning stated in Standard 7 and Standard 8 respectively.

In the context of civil engineering programme conducted by Faculty of Engineering UiTM Pahang (FCUiTMP), CDIO initiative is made to align with Outcome Based Education (OBE) requirement for Malaysian Qualification Agency (MQA), EAC and ETAC. Motivation to adapt CDIO in curriculum and teaching are to ensure knowledge and skill progression, accreditation and professional body requirements, comprehensive integrated curriculum with mutually disciplinary subjects and attributes; and ensure relevant curriculum delivery in the 21st century learning environment that are ubiquitous, flexible and technology based. CDIO framework definitely support Education 4.0, that focuses on educational development and skill has made future learning advanced skill and development (Shahroom and Hussin, 2018).

Evolution in this education framework reveals one of the challenges face by the faculty members which is the need to exercise innovative pedagogies; focusing towards student centered learning and the use of technology. In this regard, the unit of CDIO in FCEUiTMP and main campus have played important role introducing different teaching methods to enhance active learning and integrated learning experience through workshop, training and sharing best practices in faculty seminar. This paper present innovative pedagogies and active learning practice by FCEUiTMP.

ACTIVE LEARNING AND INTEGRATED LEARNING EXPERIENCES IN CDIO APPROACH

One of the main motivation of the whole CDIO approach is to make engineering more interesting and active learning is one answer to support students' motivation to engage students more on their learning (Kontio, 2015). The CDIO initiative emphasis active learning in one of the twelve standards focusing on the teaching pedagogy for engineering students (CDIO, 2014). Innovative pedagogies can provide students with concrete experiences on engineering practice. The student becoming the center of learning comparing to traditional method focusing on the lecturer. Student-centered learning approach and classroom setting has been stressed in

education reports (Oinam, 2017; Wright, 2011; Mohd. Yusoff, Abdul Karim, Othman, Mohin and Abdull Rahman, 2013; Abdelmalak and Trespalacious, 2013). Student centered learning enable individual and collaborating students participating in the knowledge delivery to provide good learning environment and beliefs. Encourage students to search for relevant knowledge rather than the educators monopolizing the transmission of information to the learners. Used the integration of technology in education as suggested (Schmid et al., 2014 and Yildirim & Sensoy, 2018) as one of teacher-student interactive method.

CDIO (CDIO, 2012) describe active learning methods engage students directly in thinking and problem solving activities. There is less emphasis on passive transmission of information, and more on engaging students in manipulating, applying, analyzing, and evaluating ideas. Active learning in lecture-based courses can include such methods as partner and small-group discussions, demonstrations, debates, concept questions, and feedback from students about what they are learning. Active learning is considered experiential when students take on roles that simulate professional engineering practice, for example, design-implement projects, simulations, and case studies. CDIO emphasis learning through standard 7 and 8;

Standard 7 Integrated learning experiences that lead to the acquisition of disciplinary knowledge, as well as personal and interpersonal skills, and product, process and system building skills.
Standard 8 Teaching and learning based on active experiential learning methods

CDIO indicates successful implementation of active learning methods by higher education institution (HEI) is shown by evidences in term of observation and self-report, a majority of instructors using active learning methods, high levels of student achievement of all learning outcomes and high levels of student satisfaction with learning methods (CDIO, 2012).

CDIO AND INNOVATIVE PEDAGOGY IN FCEUITM IMPLEMENTATION

The adaptation of CDIO initiative in FCEUiTMP through comprehensive, moving and continual cycle begin with understanding the program philosophy, adapting new methods of teaching & learning and continual assessment & evaluation process. (Figure 1).

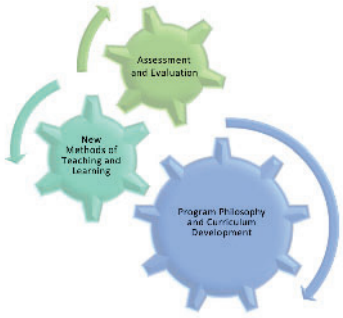

Figure 1 FCEUiTMP CDIO Implementation

The implementation of CDIO in FCEUiTMP focus on comprehensive training aimed to expose faculty members with essential techniques, instructional methods, class control and the used of current technology. Faculty members were trained to be competent in implementing CDIO in workshops, talks and seminars. Selected faculty members were chose to

experience further preparing to progress toward specialist master trainers to cascade the knowledge of CDIO.Faculty members that are equipped with fitting aptitudes which can convey the imaginative instructional method with certain and control.

The implementation inclusive training in program philosophy and curriculum development, new methods of teaching and learning; and assessment and evaluation.

3.1 Program Philosophy and Curriculum Development

CDIO framework consists of 12 standards referred to responsibilities of an engineer. The idea is to systematically strengthen the skill set which include disciplinary knowledge, personal skills and interpersonal skills set. The faculty has selected ten courses to implement CDIO and designed in sequence (Figure 2) to

demonstrate integrated learning. The horizontal and vertical articulation and integration of knowledge and skills is shown in Figure 3. Nevertheless, the faculty members are encourage to adapt active learning and integrated learning experience in classroom setting not limited to selected courses only.

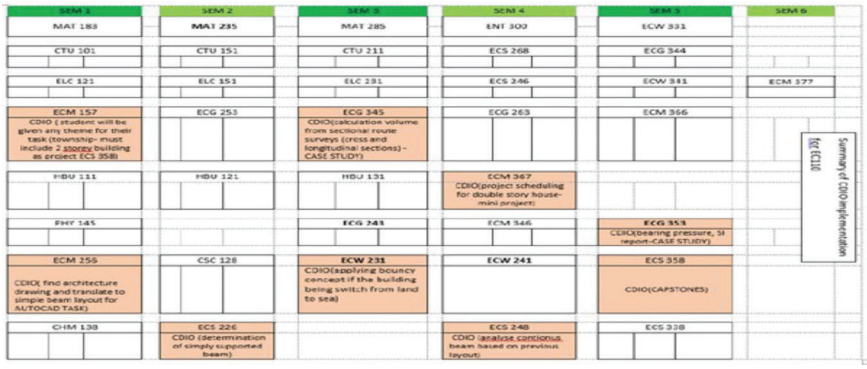

Figure 2 Sequence learning experience

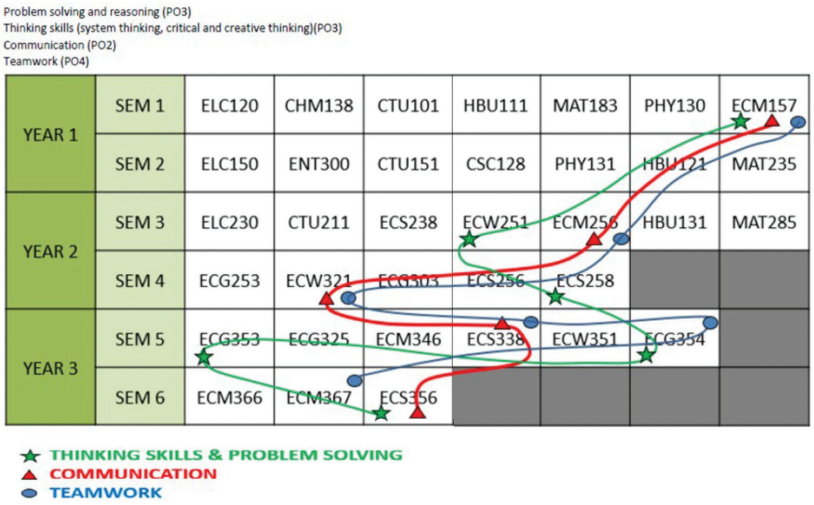

Figure 3 Horizontal and Vertical Articulation and Integration of Knowledge and Skills

3.2 New Methods of Teaching and Learning

CDIO emphasis to adopt the principle of product, process and system lifecycle development & deployment: conceiving, designing, implementing and operating (as the context for engineering education). The wisdom is to directly embed the skill set required by current business environment. Faculty members are equipped with variety teaching learning assessment mode. It provide project based on design-build experiences & teaching and learning (TL) approaches through active learning. With integrated learning experiences, faculty can be increasingly viable in helping students apply disciplinary knowledge to engineering practice and better set them up to meet the demands of the engineering profession. Training programmes have been conducted to all faculty members since 2012 with total number of 18 workshops.

3.3 Assessment and Evaluation

Students is required to demonstrate what they have learned the required skills and syllabus content in practice. The CDIO directly and clearly help to assess student learning in personal, interpersonal and product, process and system building skills, as well as in disciplinary

knowledge. CDIO provides an approach of: Introduce – Teach – Utilize - Assess to strengthen the implementation and assessment skills set. It provides variety teaching-learning-assess mode to support the EAC requirement. The evaluation of CDIO practices demonstrated in internal audit and faculty seminar.

OBSERVATION AND DISCUSSION

The observation for CDIO implementation in FCEUiTM Pahang is collected from engineering education symposium (EESCDIO) and internal audit report. The EESCDIO is the platform to share best practices from faculty member and to demonstrate the implementation of standard 7 and 8 from CDIO framework. Total number of faculty members is 39 and number of faculty member implementing is 33, almost 85% practicing innovative pedagogy in teaching. Audit report shows all nine courses selected for CDIO has 100% compliance. The detail of using innovative pedagogy as shown in Table 1.

Table 1. Innovative Pedagogy in CDIO Implementation

Type of Learning	Method of Teaching and Learning	No. Faculty member
Active Learning (Individual and Grouping)	Presentation, Mock meeting, Mind Map, Quiz, Paired, one minute paper, gallery walk, brainstorming and clustering.	9
Collaborative and Cooperative Learning	Flipped Classroom, Jigsaw classroom,	7
Use of technology	Video related topic, F-C tutorial apps, iLearn platform (forum, assessment),	6
Game based learning	Kahoot, Quizizz,	5
Experiential learning	Project-based learning, Problem-based learning, model construction, innovation competition, lab and field testing, site visit Example: Highway capacity assessment and modeling, Modeling of retaining wall, modeling of waterways channel profile, Project management competition, Build and Test competition	6

Faculty of Civil Engineering has shared the best practice implementing active learning in the class experience and presented in ESSDIO 2019. Total number of presentation by faculty members' is 10 with 90% participations (collaborative effort). FCEUiTMP shared active learning experiences presented in figure 4 – 9. Total of 10 technical papers produced on active learning on CDIO implementation.

Figure 4: Problem-Based Learning Solving for Pavement Design (Case Study and Modelling)

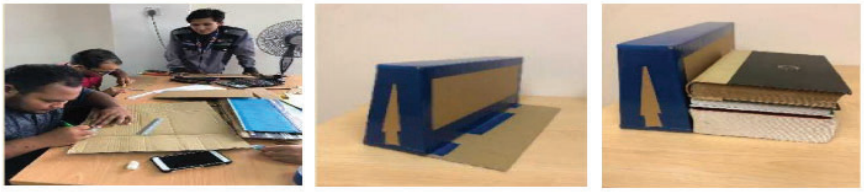

Figure 5: Identifying Lateral Earth Pressure using physical model and self-administered testing

Figure 6: Field works testing

Figure 7: Conceptual of design using collaborative learning

Figure 8: Developing Tutorial Apps

Figure 9: Brainstorming and Clustering

One example shared by a faculty member on student satisfaction has been conducted using self- administered questionnaire. The questionnaire is closed ended questions using Likert scale (1-5) and an open ended question. Questionnaire were posted via Google form. The descriptive analysis is used using analysis ToolPak, Microsoft excel 2013. This research population of 310 students, semester 4 for ECS 246 (reading and theoretical subject). The sample of 160 students answering the questionnaire. Table 2 shows students perception on different methods of teaching. The indicator are SD (Strongly Disagree), D (Disagree), A (Agree) and SA (Strongly Agree).

Based on the results, students preferred learning conducted using active learning method compare to traditional lecturing mode. The highest mean are using video and game based learning. Lowest mean reflected for conventional lecture. Comment from open ended question also show students preferred active learning. One of the comment stated,

"Add some games (filled with knowledge about this subject) to give sparks of excitements to students and build their attention to everything that is being explained."

Table 2. Students' perception on different teaching method in classroom setting

No	Item	Percentage				
		SD	D	N	A	SA
1	Traditional method	11	33	36	14	6
2	Video to present the content of subject	0	0	18	59	23
3	Mind mapping – sketching to present ideas (individual)	3	14	29	38	16
4	Mind mapping – sketching to present ideas (group)	5	6	25	47	17
5	Quiz (offline)(individual)	7	7	33	43	10
6	Quiz (offline)(group)	3	7	28	41	21
7	Group presentation	7	3	32	41	17
8	Game based learning	0	0	14	37	49

CONCLUSION

CDIO implementation in FCEUiTMP enable innovative pedagogies to be implemented in curriculum and classroom implementation. Workshops are essential to train faculty members with variety of teaching approach thus elevate confident designing instructional methods and implementation. The best practices are shared during faculty's symposium and compliance check during audit. Balance ecosystem is compulsory to accelerate change and cooperation from faculty members is the key success for CDIO implementation.

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