Enhancing OBE Performance for Civil Engineering Students with CDIO Implementation

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Abstract: This paper generally introduces Conceive–Design–Implement–Operate (CDIO) implementation in Faculty of Civil Engineering, UiTM Pahang. CDIO based teaching method is a new educational framework which organically integrates teacher's research based teaching and student's research based study in class. It emphasizes on teacher and student's leading role while simultaneously cultivates student's learning interest and thinking as well as his capability of analyzing and solving problems. This paper highlights the CDIO process framework as supporting documents to enhance Outcome Based Education (OBE) results towards sustainable development in educations. This approach helps to systematically facilitate students-centered learning to improve, embed and monitor all skills required by civil engineering students. The required skills can be indicated using the standard rubrics developed based on the CDIO approach. The rubrics were prepared based on the communication, teamwork and critical thinking skills aligned with the required PO's attainment. It is important to continuously implement this framework and monitor its effects to assess the performance and improvement gained from the initiative. An educator was also accumulating CDIO knowledge in a workshop organized by faculty as a preparation to achieve our vision. The study found that the application of CDIO in a classroom positively enhanced the PO2, PO4, PO7 and PO8 assessments. However the PO3 assessment was found to be negative due to the students' poor thinking style while solving the problems.

Keywords: CDIO, Civil Engineering, OBE, Skills

1. Introduction

Presently there is an issue of the employability of engineering graduates in Malaysia, who according to the construction industry, are lacking of skills despite their academic excellence. This issue is related to the conventional knowledge-based teaching approach for the Civil Engineering students, with inadequate attention given to improve the skills and qualities of the students. The faculty of Civil Engineering, UiTM Pahang strives to provide quality education and prepares students for various fields in construction industry, commerce and academia. CDIO is introduced in the Civil Engineering courses as to produce graduates who are fit for duty. The implementation of CDIO as part of our syllabus is to achieve OBE requirement which works towards sustainable development of education. The CDIO in Civil Engineering course acronym stands for Conceive (basic knowledge of civil engineering), Design (creating the plans and drawing), Implement (transforming the design into a product) and Operate (delivering, implementing product, process or system to satisfy intended value).

According to OBE approach, the measurement of students' progress is needed to determine students' competencies as to improve their academic performance. The POs and PEOs results must be optimised within the theory-based courses and strengthened with the application of skills to promote active learning activity in the classroom to ensure its relevancy to the current topic. Exploring teaching content integrating "teaching - learning - practice" with skills was a valuable approach to enhance participation of students in class. As an educator, they need to improve the quality of teaching and learning as to meet or exceed international standards. The evolution of knowledge delivery and assessment is necessary as to fulfil the needs of the stakeholders (students, parents, alumni, employers and nations) and industry. This

paper is thus prepared to introduce the CDIO concept to educators as supporting documents in enhancing OBE results as to gain sustainable development in education.

2. CDIO Based Teaching Method

CDIO is known as a pedagogy which organically integrates researches done by educators and students. It involves interactive learning process in and outside of classes and sharing of knowledge, together with extensive reading of textbooks and other materials to form a comprehensive concept of education system. According to Zhongwei, Hongguag and Jianhua (2011), the implementation of CDIO also emphasizes on educators and students' leading role simultaneously, cultivates students' learning interest, stimulates their thinking and trains their capability of analyzing and solving problems. According to CDIO, there are twelve standards to be satisfied (as shown in Table 1 below) during the implementation of CDIO Based Teaching Method in Civil Engineering course. The purpose of these standards are to define the distinguishing features of CDIO program, serve as guidelines for educational program reform and evaluation, create benchmarks and goals with worldwide application, as well as to provide a framework for continuous improvement.

Table 1. CDIO Standards (CDIO Workbook, 2012)

Standard		Description
1	Context	Adoption of the principles that produce, process and improve the development and deployment of the system.
2	Learning outcomes	What students should know and able to do at the conclusion of their engineering course.
3	Integrated curriculum	The curriculum is designed with mutually supporting disciplinary courses that include an explicit plan to integrate personal and interpersonal skills and product, process and system building skills.
4	Introduction to Engineering	An introductory courses offered that provides students with framework to understand engineering practice in the context of CDIO
5	Design – Implement Experience	Ideally should be begin in the freshman year and continue through graduation.
6	Engineering work spaces	Provide the physical environment to support and encourage hands – on learning of product, process and social building skills concurrently with learning disciplinary knowledge.
7	Integrated learning experience	Provide pedagogical environment.
8	Active learning	Teaching and learning based on active experiential learning methods that engage students directly in thinking and problem solving activities.
9	Enhancing of faculty skill competence	Provides support and training for faculty to improve their competence in personal and interpersonal skills and process, product and system building skills.
10	Enhancing of faculty teaching competence	Provides support for faculty to improve their competence in integrated learning experiences, in using active experiential learning methods and in assessing student learning.
11	Learning assessment	The measure of the extent to which each student achieves specified learning outcomes.
12	Program	This process evaluates the university program against these twelve standards

	evaluation	and provides feedback students, faculty and other stakeholders for the purpose of continuous improvement.

The CDIO standards were mapped with the program outcomes of civil engineering diploma courses (Table 2) to enhance their assessment based on identification skills. Basically, POs is part of OBE and divided into three types of domain which are cognitive, affective and psychomotor. Learning that focuses on examination and physical involvement in the laboratory activities is attributed to cognitive and psychomotor which serve as the core domains. Affective domain, on the other hand, describes learning objectives that emphasize on students' feeling, tone, emotion, or a degree of acceptance or rejection. These domain objectives vary from simple attention to selected phenomena to complex but internally consistent qualities of character and conscience. In this study, the CDIO skills consisting of communication, teamwork, and critical thinking were identified as a supporting document to assess affective domain skills of the civil engineering students.

Table 2. Program Outcomes (POs) for Civil Engineering Courses (Diploma)

Program Outcome	Description
PO1	Ability to acquire and apply basic knowledge of science, mathematics and engineering.
PO2	Ability to communicate effectively, not only with engineers but also with the public.
PO3	Ability to identify, formulate and solve engineering problems using thinking skills and engineering reasoning.
PO4	Ability to act effectively as an individual and as a group with leadership capabilities.
PO5	Understanding of the social, cultural, global, environmental responsibilities, ethics and the needs for sustainable development.
PO6	Acquiring the capacity to undertake lifelong learning and having the knowledge of contemporary issues.
PO7	Ability to design and conduct experiments as well as to analyse, interpret data and to construct engineering drawing.
PO8	Ability to function in multidisciplinary teams.
PO9	Having the knowledge of management, financial and entrepreneurship.

2.1 CDIO Skills with Rubric

In recent years, studies have been conducted by researchers in many countries to determine the technical and personal abilities required by engineers in current industry (Awang & Daud, 2015). Engineering graduates are required to have excellent skills and abilities to fulfill current industrial demands. However, they are unable to achieve the requirements as there are still inadequacies in several aspects. This has caused graduates' lack of practical aspect of engineering in spite of their strong foundation in the fundamentals of engineering science and computer literacy. Therefore, educators are responsible to assist the students in developing their skills by understanding the definition of each skill and preparing the necessary rubrics for assessment purposes. In Faculty of Civil Engineering, UiTM Pahang, the CDIO skills have been implemented, focusing on communication, teamwork and thinking skills attached with the necessary rubric for assessment.

2.1.1 Communication Skills

Communication can be defined as the activity of conveying information through the exchange of thoughts, messages or information by speech, visuals, signals, writing or behavior.

Communication also must involve meaningful exchange of information between two or more persons. In a simple word, communication is vital in transmitting and receiving information. In theory, the type of communication can be categorized to verbal, non-verbal, written and visual. Verbal communication deals with the use of spoken language using mouth to transmit information or message. The second type is non-verbal, a type of communication that manages to convey the sender's message without having to use words such as gesture, body language, posture or facial expressions. The delivery of message or information via email, letter, report, and memo, referred as written communication can provide a proper record with appropriate feedback. This differs from the visual communication like topography, symbols, designs, or photography that uses visual aids as a medium to deliver information. After considering all relevant categories in communication, educators should prepare standard rubrics as shown in Fig. 1 that primarily focuses on verbal communication, the skills which students mostly have difficulties with. It can be used to measure the PO2 (Ability to communicate effectively, not only with engineers but also with the public) which is applicable to all students and various conditions. The rubric was found useful to properly evaluate students' communication skills during presentation or any related activity in classroom.

Category	Remark		
	Bad	Mediocre	Outstanding
Clarity	1	3	5
	The information presented must be clear and understandable by the audience.		
	Chaotic/ Very difficult to understand	Easy to understand but some points are not clear	Excellent. Clear and concise
Preparedness / organization	1	3	5
	The completeness of the slide presentation and self-confident.		
	Messy and Disorganized	Organized but the presentation is not smooth	Organized and well prepared
Gestures	1	3	5
	Gestures of the presenter		
	Minimum gestures	Medium gestures	Express the main point together with excellent gestures
Voice	1	3	5
	The speed of delivery and voice, loud and clear		
	Anxious and Uneasy	Clear	Clear with dynamic projection
Eye contact	1	3	5
	Eye contact with the audience		
	Minimum eyes contact	Medium eyes contacts	Excellent
Attire	1	3	5
	The way of dressing and choosing appropriate attire. Wearing formal attire		
	Inappropriate	Neat	Excellent

Fig. 1 Communication Rubric

2.1.2 Teamwork Skills

According to Oxford Dictionary, teamwork is defined as a group of people organized to work together or interdependently in order to cooperatively meet the needs of their customer by accomplishing a purpose or goal. In our daily life, social interaction occurs in various social groups such as family, school, society as well as organization and company – all of which teamwork is present. Eva (2014) stated that students as social creatures need others to support their success of life; they need to develop cooperation with others to achieve their goal. Therefore, students must form an effective team by communicating clear expectations towards the expected teamwork and collaboration. In this collaboration, they must respect and show cooperation with regular review being made necessary to the group before making a decision. It will make each team member feel reliable, important, special and happy during teamwork activities.

The successfulness of teamwork depends on a good leader who consistently motivates and guides his team towards clear work pattern and goal. According to Hamidreza, Ismail and

Yusof (2012), teamwork come from working in pairs or small group by doing group assignment and presentations as a team attached sharing ideas among team members. Knowing the benefits of teamwork to students' development, the Faculty of Civil Engineering, UiTM Pahang has made teamwork activity as compulsory for the course with PO4 and PO8 attainments using applicable standard rubric as shown in Fig. 2. This rubric was prepared to assess the teamwork activities involving students.

Category	Remarks		
	Bad	Mediocre	Outstanding
Contribution	1	3	5
	Assesses what the student provides the group in the form of materials, effort or leadership. The degree to which each student provides materials or skills that are integral to the group's ability to complete the given assignment.		
	Did not contribute work/ideas or complete any assigned tasks.	Contributes work/ideas that only meet the group's baseline expectations or completes all assigned tasks, but does not show a willingness to assist others.	Contributes work/ideas required or takes initiative to be a good leader, assists in delegation of group activities, guides the group to assure end product is high quality and complete.
Cooperation	1	3	5
	The act of working together with team members		
	Exhibits a hostile attitude toward the project, assigned tasks, and group members causing many problems within the group environment.	Offers few ideas, or at times monopolizes the sharing of ideas, may not understand alternative viewpoints. Does not cause problematic situations within the group.	Exhibits a positive attitude toward the task and engages effective information sharing, discussion ideas, active listening. Actively seeks ways to avoid or solve problematic situations within group
Self-Management	1	3	5
	Assesses student's work ethic, ability to meet deadlines, ability to prioritize projects, and the ability to focus on the task at hand.		
	Did not meet any deadlines, hampered the group's ability to complete the overall project, and/or shows no focus.	average work ethic by meeting some of the deadlines, prioritizing personal projects and partially focus on the assigned tasks	Demonstrates an excellent work ethic: meets all deadlines, prioritizing personal projects, fully focuses on all assigned tasks.
Communication	1	3	5
	Process of exchanging information between individuals in the group		
	Has trouble listening with respect, and takes over discussions without letting other people have a turn.	There is a general atmosphere of respect for team members, but some members may not be heard as much as others. Some members may not feel free to turn to others for help. Members may avoid discussing some topics.	Team members communicate openly and treat one another with respect. All members listen to ideas. The work of each person is acknowledged. Members feel free to seek assistance and information, share resources and insights, provide advice, or ask questions of each other.

Fig. 2 Teamwork Rubric

2.1.3 Thinking Skills

Thinking is the ability for human to solve a problem or task intelligently or rationally, thus provide a reasonable explanation for the solution. All human achievements and progress are simply the products of thought (Tang, Subadrah & Bouphan, 2014). It is also a combination of the related structures and processes of perception, memory, forming ideas, language and use of symbols which is inclusive of imagining, recalling, solving problems, free association, daydreaming, concept formation, and variety of other procedures (Nadezda, 2015). The thinking style deemed crucial in many engineering courses is critical thinking. According to Flor et al. (2013), the term critical thinking is defined as the intellectually disciplined process of actively and skilfully conceptualizing, applying, analysing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action. In its exemplary form, it is based on universal intellectual values that transcend subject matter division: clarity, accuracy, precision, consistency, relevance, sound evidence, good reasons, depth, breadth and fairness. In the meantime, the creative thinking has a process which involves the ability to produce original ideas, to perceive new and unsuspected relationships, or to establish a unique and improved order among seemingly unrelated factors. It is slightly similar to the interpretation by Sayadian and Lashkarian (2015) who said that the process includes defining, researching, ideating, verifying and evaluating which are classified under abstract thinking and concrete thinking. Flor et al. (2013) described creative thinking process involves the ability.

Most researchers and educators consider that critical thinking is becoming increasingly important and suggest ways to teach critical thinking such as: various techniques to keep the class interesting, open-book tests and student-authored exam questions, critical thinking debates, a set of cognitive skills that can be applied to teaching, utilizing and assessing critical thinking skills and transfer of critical thinking skills in higher education (Nadezda, 2015). The approaches applied in a classroom can be used as a support document for an affective domain assessment by constructing standard rubric as shown in Fig.3. This standard rubric was developed based on the basic criteria for PO3 and PO7 attainments which can be later adopted for upgrading purpose.

Category	Remarks		
	Bad	Mediocre	Outstanding
Explanation of issues	1	3	5
	A statement or clarification that makes the issue easy to understand.		
	Issue/ problem to be considered critically is stated without clarification or description	Issue/ problem to be considered critically is stated but description leaves some terms undefined,	Issue/problem to be considered critically is stated clearly and described comprehensively,
Analysis of information	1	3	5
	Selecting and using information to investigate a point of view or conclusion		
	Information is taken from source(s) without any interpretation/evaluation. Viewpoints of experts are taken as fact, without question.	Information is taken from source(s) with some interpretation/evaluation, but not enough to develop a coherent analysis or synthesis.	Information is taken from source(s) with enough interpretation/evaluation to develop a comprehensive analysis or synthesis. Viewpoints of experts are questioned thoroughly.
Organization and style	1	3	5
	Systematic logical connection between one information to another		
	No considerable organization; Lacks transitions and coherence.	Shows a logical progression of ideas, may move from least to more important idea. Some logical links may be unrelated or unclear.	Uses a logical structure that is appropriate to the issues, purpose and audience. It clearly guides through the chain of reasoning or progression of information.
Conclusions and related outcomes	1	3	5
	The outcome of the research		
	Fails to identify conclusions, implications, and consequences, or conclusion is a simplistic summary	Conclusion is logically tied to information (because information is chosen to fit the desired conclusion); some related outcomes (consequences and implications) are identified clearly.	Conclusions and related outcomes) are logical and reflect student's informed evaluation and ability to place evidence and perspectives discussed in priority order.

Fig. 3 Thinking Rubric

3. Learning Pattern

Civil Engineering students enrolled in universities are expected to have solid mathematics and physic background primarily because engineering curriculum strongly depends on these two fundamental sciences. This fundamental knowledge in Civil Engineering requires understanding rather than memorizing for in depth learning of the courses. Typically most of the courses involve students learning from instructors, reading the textbook and solving textbook problems. This creates a passive engagement of the students which in return leads to minimal retention of knowledge as shown in Fig. 4. Generally, the pattern of information delivery influences students' knowledge retention. Thus, educators are required to apply active learning in a classroom that involves interesting pedagogy approach. The application of active learning encourages students centred-learning to enhance the students' performance. Therefore, the implementation of CDIO emphasizes on the students skills which reflect affective domain assessment.

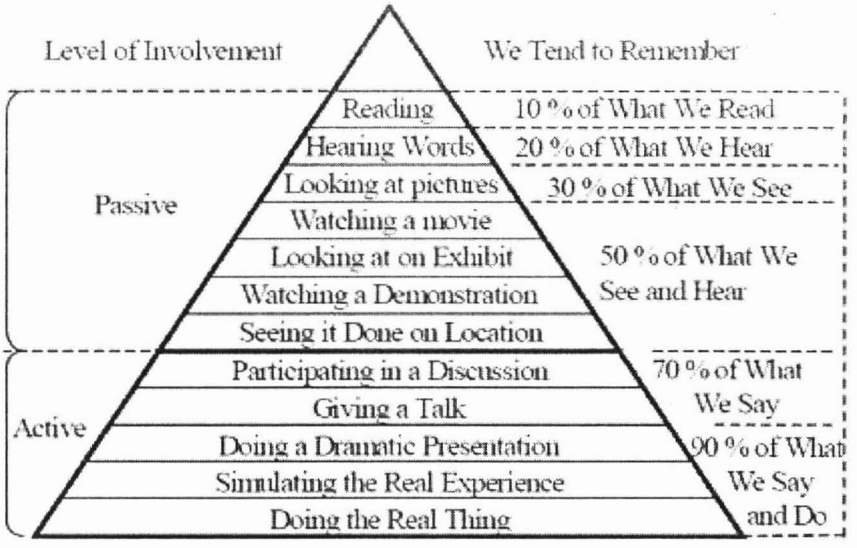

Fig. 4 The cone of learning (Hamoudaa & Tarlochan, 2015)

4. OBE Performance

OBE performance was obtained through test, assignment and final paper for each civil engineering student in the Faculty Civil Engineering, UiTM Pahang. Table 3 shows that the selected POs were compared for 2 semesters with the same number of students to observe the POs attainment before and after applying CDIO. Most of the POs had an increase in percentage compared to the previous semester due to the application of CDIO skills. PO7 gathered the highest percentage increase of 27.2% while PO3 had a decreasing of percentage to 1.5% due to the lacking of CDIO approach on the thinking skill. The application of CDIO approach in the courses affected students' performance results, present effect and teamwork collaboration during the development of a practical engineering project.

Table 3. Comparison of POs Attainment before and after CDIO Implementation

Program Outcome	Percentage POs (%)	
	Previous Semester	Current Semester
PO2	72.8	77.2
PO3	68.3	66.8
PO4	68.3	75.0
PO7	61.1	88.3
PO8	54.3	62.1

5. Conclusion

In conclusion, the implementation of CDIO in the teaching of Civil Engineering courses, UiTM Pahang showed significant increase in the POs attainment for students' affective domain. Referring to OBE pattern, the measurement for each student will be based on the PO mapping to the related course. However, there were some issues related to assessment of POs attainment for affective domain that emphasized more on emotion of each student. The issues

should be immediately addressed as to prepare the students for the demanding engineering education and industry.

Thus, this paper introduces a brief CDIO concept to the civil engineering educators, of UiTM Pahang focusing on communication, teamwork and thinking skills mapped for PO2, PO3, PO4, PO7 and PO8 through standard rubrics that assess each skill. This is due to the lacking of affective domain skills assessment. Using the CDIO concept, students' ability can be polished and improved with the implementation of active learning approach in a classroom However, only PO3 was decreased after application of CDIO based on the comprehensive assessment report of contributions obtained from class activities, test and final examination. This is due to the pattern of student's thinking in terms of creative and critical thinking was unchangeable and poor while solving a problem.

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