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Outcome Base Education (OBE) and Conceive Design Implement Operate (CDIO) : A Case Study of Electrical Engineering Student Project I & II at Malaysian Polytechnic

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Abstract

This paper seeks to explain the philosophy of Outcome Based Education (OBE) and a Conceive-Design-Implement-Operate (CDIO) approaches. A case study of student activities based on OBE implementation in the project I and II in Electrical Engineering department of Polytechnic Malaysia is explained. This is followed by the evaluation of students' activities for both projects using the CDIO framework. It is intended to help educators understand how the OBE used and translated in teaching and learning can be improved with the integration of CDIO approaches. Findings of the study will lead to suggestions for the betterment and improvement of students' project particularly project I and II as well as other courses carried out by the Electrical Engineering department in Malaysian polytechnic from the CDIO viewpoint.

Keywords: Outcome Based Education (OBE) , Conceive-Design-Implement-Operate (CDIO), Student Project Activities, Teaching and Learning domain, Malaysia Polytechnic.

1. Introduction

The globalization of industry and engineering practices make the role of future engineering graduate becoming more challenging and competitive. Therefore, the engineering education system for the future (2020) should be based on engineering practice for easy mobility, flexibility and adaptability to the new changing in science and technology as well as industry requirement (Nor1 et al. 2015). In realizing the importance of producing a highly

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competence engineering graduate for the future, the Malaysian Ministry of Higher Education (MoHE) has placed a considerable priority to the high learning institution especially Polytechnic Malaysia to produce engineering graduate who are competitive in the future marketplace. In order to accommodate these new challenges and needs, the engineering education in Polytechnic Malaysia should capitalize these opportunities and challenges. It is essential for Polytechnic Malaysia to enhance the engineering education in order to produce engineering graduate of the 2020 who are equipped with strong knowledge, understanding of professional and ethical responsibility, ability to communicate effectively, understand the impact of solutions in global and societal context, ability to engage in real life-long learning, multidisciplinary teams, solving engineering problems, creativity, ability to use technique, skills, and modern scientific and technical tools necessary for professional practice (Megat Johari et al.,2002).

In implementing the Outcome Base Education (OBE) for the engineering education, Malaysia has been initiated and driven by the Quality Assurance Department, MOHE. The Polytechnic Malaysia embedded and implemented OBE in the curriculum since year 2010 [Rumzi et al, 2013). To further enhance the quality and employability rate especially among the engineering graduate, the Note of Understanding (NoU) was successfully signed in May 6 2014 between the Department of Polytechnic Education and the Singapore Polytechnic on behalf of Temasek Foundation. Consecutively, Conceive-Design-Implement-Operate (CDIO) education framework was introduced to the Malaysia Polytechnic.

2. Outcomes Based Education (OBE)

OBE is an educational theory that focuses on what students can actually do after they are taught. An OBE curriculum clearly focusing and organizing everything in an educational system such as what is essential for all students to be able to do successfully at the end of their learning experiences. OBE also has been defined and proposed to be the best methodology to help students to learn more effectively within their educational environment. It is clearly stated in the curriculum of the intended teaching outcome and standard (Azida et al. 2012).

Elements of OBE curriculum consists of Programme Learning Outcomes (PLO) and Course Learning Outcomes (CLO). The PLO are often derived from the vision and mission of the Department of Polytechnic Education with the consultation with employers, field experts, and accreditation and professional bodies if appropriate. Course Learning Outcomes (CLO) describes what the student is able to perform as a result of their learning experiences within the course. These are determined by the course lecturer, or by a team of lecturers who teach the same course.

An OBE curriculum is a product model dependent on what learning outcomes set. It is explained in eight (8) domains learning outcomes in the Malaysia Quality Framework (MQF) which also emphasize in Malaysia Quality Assurance (MQA). There are; Knowledge of Discipline Area, Technical Skills (Practical Skills), Values, Attitudes and Professionalism, Social Skills and Responsibilities, Communication, Leadership and Team Skills, Problem Solving and Scientific Skills, Information Management and Lifelong Learning Skills and Managerial and Entrepreneurial Skills. In addition, there are seven generic students' attributes (GSA) adopted by Ministry of Higher Education (MoHE) Malaysia to form the program learning outcome in each program in polytechnic. These includes skills such as Communications Skills, Critical Thinking and Problem Solving Skills, Teamwork Skills, Moral and Professional Skills, Leadership Skills, Information Management Skills and Continuous Skills, and Entrepreneurships Skills (Jabar & Lee, 2011).

Eventually, OBE is a process that involves the restructuring of curriculum, assessment and reporting practices in education that reflect the achievement of high order learning and mastery rather than the accumulation of course credits. The primary aim of OBE implementation in Malaysia Polytechnic is to facilitate desired changes within the students, by increasing knowledge, developing soft skills and/or positively influencing attitudes, values and judgment within the context. Thus, these process will prepare students with knowledge and skills and attitudes required by industry as well as can improve graduate quality and employability rate. Today all curriculums in Polytechnics are accredited by MQA either full or self-accreditation status.

3. Concieve design Implement Operate (CDIO)

In recent years, the industry has learned that engineering graduates are lacking in many skills and abilities required in real world engineering situations. They initiate that traditional teaching methods which is a combination of lectures, tutorials and practical sessions (face to face) or classroom concept often failed to achieve the goals required by industries. This is because a traditional teaching method seems unable to fully develop vital problem-solving and project-based skills required in real world engineering projects. In addition, it is also lack of engineering approach in teaching method. To address this, the Conceive, Design, Implement and Operate (CDIO) initiative has been introduced. This concept was founded in late 1990s the by Massachusetts Institute of Technology (MIT). In year 2000 the MIT collaborated with three (3) other institutions such as Swedish Institutions, Chalmers University of Technology, Linkoping University and Royal Institute of Technology (KTH) [karl et al, 2003).

In Singapore, the CDIO framework has been adopted by Singapore Polytechnic (SP). The main aim is to provide students with a balance and holistic education with integrating and teaching such as domain knowledge, people and process skills and value and ethics (Pee & Leong, 2005). Figure 1.0 shows the twelve CDIO Standards used by SP. This standard has been embedded in their curriculum to boost graduate employability rate as stipulated in CDIO (Johan et al., 2006).

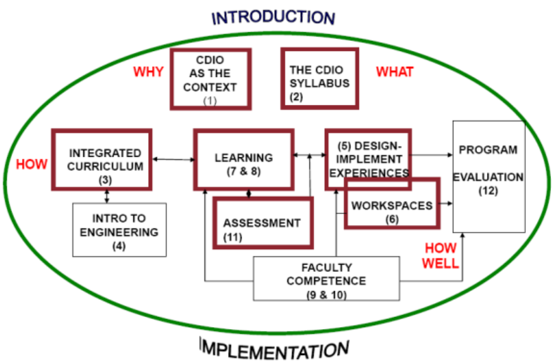

Figure 1.0: Twelves' (12) CDIO Standards

Based on the twelve's (12) CDIO standards (Yin, 2010), the syllabus were designed to accommodate the learning and teaching activity such as learning to know, learning to be, learning to live together and learning to do as referring to four learning pillars stated by UNESCO (Zhou, 2015). Table 1.0 shows the learning and teaching activity referring to the related CDIO standard apply in syllabus.

Table 1.0: Learning and Teaching Activity related to the CDIO Standard Appl in the Syllabus.

What: CDIO Syllabus		How: 12 Standards of Best Practices	
Disciplinary Knowledge (Learning to Know)	Knowledge of underlying maths & sciences, Core fundamental knowledge Advanced fundamental knowledge	Curriculum	Standards 1, 2, 3, 4
Personal Skills (Learning to Be)	Analytical reasoning & Problem solving, Experimentation & knowledge discovery, System thinking, Personal skills and attributes, Professional skills & attributes	T & L Activities	Standards 5, 7, 8
Interpersonal Skills (Learning to Live Together)	Multi-disciplinary teamwork Communications Communication in a foreign language*	Assessment	Standards 11, 12
CDIO Skills (Learning to Do)	Conceiving, Designing, Implementing & Operating Systems in the Enterprise/Business & External/ Societal Context Conceiving and engineering/technology systems Designing/ Formulate Implementing/ Develop/Produce Operating/ Evaluate	Faculty Competence	Standards 9 & 10
		Workspace	Standards 6

The CDIO concept was elaborated in curriculum based on the design process in actual systems and product development as practice in the industry. Table 1.0 shows the learning to do in teaching and learning activity consists of the CDIO skills that accommodate CDIO standard 9 and 10. It captures the rise of skill apply in industry to produce the product, started with conceiving follow by design/formulate then implement/develop/produce and lastly operate/evaluate. This conforms to one of four pillows in UNESCO learning domain (Learning to do). As a result, implementation of CDIO concept is more accurately imitating product life cycle of the real life of engineering scenarios (Peng et al., 2006; Bai et al., 2012;Imrie & Xie, 2008). Therefore, by using the product life cycle in learning process, students will develop better skills. This is because in each stage of the CDIO (Conceive- Design-Implement- Operate) the students are able to develop different skills as required by engineers. Table 2.0 shows the CDIO stages with different skills (Raymond et al., 2015). Three others are learning and Teaching activity in CDIO (Disciplinary knowledge, personal skills and interpersonal skills) and also matching with the teaching and learning activities in the UNESCO learning domain (learning to know, learning to be and learning to live together) as well as accommodating with the related CDIO standard as shows in Table 1.0.

Table 2.0 CDIO Stages With Different Skills.

Stage	CDIO	Develop Different Skills
1.	Conceive	This initial stage involves defining the needs and problems to be solved and technology required, considering the enterprise strategy and regulations. Here they develop the concept, technical and business plans.
2.	Design	This stage focuses on creating the *design such as* the plans, working drawing, and algorithms that describe what will be implemented in completing the project.
3.	Implement	The *implement* stage involves transforming the design into the product solution. This includes manufacturing, coding, testing and validating.
4.	Operate	This is the final stage and involves operating the implemented product to deliver the intended function, including maintaining, evolving and retiring the system.

In addition, the four learning domain in CDIO are complement to the eight learning domain in MQA. However, the domain number 2 - technical skills/practical skills in the MQA were not elaborated details in the OBE curriculum as compared to the CDIO learning domain (CDIO skills) elaborated in CDIO curriculum (Kristina & Anette, 20112). In CDIO learning domain of Conceiving, Designing, Implementing and operating mainly focus on societal and environmental context. This domain is holistically focused on the engineering work in the industry. With that, students are not only learning but engaging in solving the engineering problem (Karl et. Al., 2003; John et al., 2006).

4. Outcome Based Education (OBE) Approached in Project and Project II Course

Course learning outcome is a sign to differentiate between OBE and conventional curriculum approached in teaching and learning in polytechnic. Project I & II in Electrical Engineering Department (EED) in Malaysia Polytechnic curriculum consists of four main course learning outcomes. This is written in project I and II course outline; the first CLO is to conduct study and research on the selective project (hardware, software and both category). The second CLO is to plan the activities and conduct project implementation based on chosen category. The third CLO is to carry out project construction procedures (hardware project) or to produce flowcharts and draft algorithm for system programme (software project) systematically. The last CLO is to demonstrate continuous learning and information management skill while engaging in independent acquisition of new knowledge and skill to develop the project (kurikulum, 2010). These courses learning outcome show that students will be exposed to problem-based and active learning. Essentially, students will be more engaged, motivated and alert in their study as well as knowledge and skills acquires during the conduct of the project I and II. This knowledge and skills acquire from the courses will enable them to participate in the job market.

The project I and II requires students to conduct the project in a group of 3 to 4. They have to work in a team to complete the project within two semesters (semester 5 & 6). At the end of the period (semester 6) students should be able to produce and demonstrate their final project or final product. All these learning activities will go through assessment process which is based on Course learning Outcome (CLO). This assessment are evaluated using rubric on learning domain and skills needs and will be graded as excellent, very good, good etc. Figure 1.0 shows the basic assessment items (portfolio and product) vs. CLO coursework marks distribution for Project I & II.

Coursework / CLO	Portfolio				Product	
CLO	Attendance	Involvement	Initial Proposal	Logbook	Presentation	Final Proposal
CLO1			√ - C	√ - C		
CLO2				√ - C	√ - C	√ - C
CLO3				*√ - P		
CLO4	√ - A	√ - A		**√ - A		

Coursework / CLO	Portfolio				Product	
CLO	Attendance	Involvement	Logbook	Presentation	Final Proposal	Model / System
CLO1			*√ - P			
CLO2			√ - C			√ - C
CLO3				√ - C	√ - C	
CLO4	√ - A	√ - A	**√ - A			

Legend:
C - Cognitive ; P - Psychomotor ; A - Afective

Figure 2.0: Assessment items Vs. CLO (a) Project I (b) Project II

Figure 2.0 show that the project assessments form is looking on the three main learning domains in education theory such as cognitive (C), psychomotor (P) and affective (A). In project I and II the level of the three domain learning based on taxonomy bloom written in the curriculum document is applied (C3), Mechanism (P4) and value/behavior (A3) respectively. In Applying (C3): The student will be able to use a concept in a new situation or unprompted use of an abstraction. They supposed to apply what has been learned in the classroom into novel situations in the work place. Mechanism (P4) is the intermediate stage in learning complex skills. Learned responses have become habitual and the movements can be performed with some confidence and proficiency. However, Valuing (A3) is based on the internalization of a set of specified values, while clues to these values are expressed in the learner's over the behavior and are often identifiable.

Level C3, P4 and A3 are the level set by the polytechnic for diploma student as required by MQA for three respective learning domains (Hasbullah et. Al., 2011). This means the knowledge (C3), skills (P4) and attitudes (A3) acquired by students while conducting their project is adequate to fulfill industry requirements as a diploma graduate.

5. Student Project Activities for the Courses of Project I and Project II in Malaysia Polytechnic

As stated, this paper will explain about study conducted on student's activities for project I and project II in Electrical Engineering Department of Malaysia Polytechnic. Activities conducted applied learning method or approach that lead to the achievement of learning outcome written in curriculums such as acquire knowledge, practical skills and critical thinking and problem solving skills.

The study is summarized into 4 main activities conducted by student during a study on Project I and II:

- 5.1 Project selection
- 5.2 Project Planning and Design
- 5.3 Project Implementation (active experiential learning)
- 5.4 Project demonstration and presentation

5.1 **Project Selection**

Project selection is a process aim to identify the title of the project. The process requires students to gain knowledge on related field through literature study. Knowledge gained will be brainstorm in a group discussion which is essential in producing an innovative and productive project as well as solving daily problems. Ideas and values generated by members of the group were discussed and select eventually. The values such as intelligent, market values, creative, innovative, critical thinking and others are vital in decision making. These criteria will be imposed during selection of project title. The title which comply with the criteria stated will be selected. Once the tittle is selected the next step is to nurture further research to support the idea selected. Obviously, the steps resemble CLO1 which is to conduct study and research on the selective project (hardware, software and both category). As a result this will generate a well design process and a better project can be produce.

5.2 **Project Planning and Design**

In order to succeed in conducting the project students have to plan the action or activities to be carry out within the project timeline. In project I and II, students were given two semesters to complete the project. They need to include execution of design and build experiences in their action plan. They also should take into account elements of interactions like forming effective teams as well as engineering subject matter and learning such as thinking about the project design and testing, implement, validate, demonstrate, present the final project or product and finally prepare a report. Figure 3.0 shows a sample of project timeline for the electrical engineering project I and II.

TABLE OF PROJECT ACTION PLAN

Mision;
To Finish the Project within 24 Months (Dis 2011 – Dis 2012)

Student Name:

VISION:
To Fulfill and award Diploma in Electrical and Electronic Eng. 2013

Objectives;
a. To design the model smart house system based on PIC microcontroller
b. To implement and integrate the various sensing methods for security and safety in smart house model
c. To test and verify the function of the smart house model based on the PIC microcontroller programming language

No.	Activities	MONTH/YEARS DIS' 11	Jan' 12	Feb' 12	Mar' 12	Apr' 12	Mei' 12	Jun' 12	Jul' 12	Ogos '12	Sept' 12
1.	Literature review and identify/select the project										
2.	Prepare methodology (method, system block diagram, circuits, data/ testing procedure, design the project etc)										
3.	Prepared project proposal										
4.	Test the circuits on protoboard and troubleshooting										
5.	Design the software flowchart and programming										

Prepared by:
Date:

TABLE OF PROJECT ACTION PLAN

Mision;
To Finish the Project within 12 Months (Dis 2011 – Dis 2012)

Mohd Daud bin Isa

VISION:
To Fulfill and award Diploma in Electrical and Electronic 2013

Objectives;
a) To design the model smart house system based on PIC microcontroller
b) To implement and integrate the various sensing methods for security and safety in smart house model
c) To test and verify the function of the smart house model based on the PIC microcontroller programming language

No.	Activities	MONTH/YEARS Jul' 12	Ogos '12	Sept '12	Okt' 12	Nov, 12	Dis' 12	Jan' 13	Feb' 13	Mar' 13	Apr' 13
4.	Testing the hardware and software on protoboard and modified if necessary										
5.	Design the PCB, install components and test the circuits.										
6.	Start report writing										
7.	Test the project using the programming and modified if necessarily.										
8.	Design the casing and burn in test										
9.	Submitted project report										

Prepared by:
Date :

Figure 3.0: Student project timeline

Figure 3.0 shows that students will have to go through the process of product lifecycle begin with study of literature and methodology, design, testing and implement the project and lastly to produce the final project and demonstrate the project (burn in test). During the design stage of innovative product and system, the students need to apply the higher order thinking skills such as critical, synthesis and creative thinking. This thinking skill is projected to be able to produce a project or final products with specifics solving problem skills as needed by target group. This activity conforms to the CLO2 (to planning the activities and conduct project implementation based on chosen category) of course learning outcome Project I and II.

5.3 **Project Implementation (Active Experiential Learning)**

The key tasks of hardware fabrication, installation and testing and software development were carried out during this stage. Upon completing the hardware installation and testing, students need to code the program and generate the executable file and download it into the project. From this stage, students need to work harder to produce the hardware and software of the project. More time spent by the students as well as supervisor to troubleshoot hardware and software if the project is not working accordingly. Motivation and encouragement by the supervisor are crucial at this stage, especially when the project failed to function after repeated trials. On the other hand, the excitement will be there once the project works fine although for the first time. There are several tasks conducted by the student in Project I and II during project implementation stages such as PCB Electronic Board preparation, electronic component installation and soldering process – Mainboard and input/output circuit, and the last process is programmed and testing and troubleshooting and validating the project. The tasks exhibit skills application by students such as problem-based and problem solving in their activities. Additionally, active and experiential learning was also applied. These active and experiential learning was eventually imposed students with the theory of Constructivism and Behaviorism in education. As a result, the students were more imposed and engaged, motivated and attentive in their study as well as skills acquisition (teamwork, work ethic, analytical and communication) (Azida et al., 2012; Kristina et al., 2012). These are essential skills needed by the industry for polytechnic's graduates. These activities eventually comply to fulfill the CLO2, CLO3 and CLO4 of course learning outcome for Project I and II.

5.4 Project Demonstration and Presentation

After completing the entire project cycle (2 semesters), the project is ready for exhibition and presentation. An opportunity to exhibit the projects to an internal or external panel able to expose students to new experience such as presentations skills and exhibition preparation. All these require students to train further. In polytechnic, these activities will be conducted in a one day program called Final project exhibition and presentation day.

During the exhibition, the project will be asses by the internal and external panel. The marking scheme rubrics were based on three criteria such as Psychomotor Skill (i.e. Circuit simulation and PCB layout, Photolithography and Etching, Component and Breadboard Circuit testing, Soldering and Model, Program / Algorithm, Testing, and model etc.). Affective -Lifelong Learning Rubric (Attendance, Involvement, Logbook etc.) as well as Cognitive marking scheme (Logbook, Model / System, Presentation and Proposal, and final report). This marking scheme shows that all the activities conducted by the students are assessed based on the three learning domain in taxonomy bloom such as Cognitive, Psychomotor and Affective. This scheme will prepare the students with knowledge, skills and good etiquette needed by industry for future workers.

6. Evaluation on project I AND II activities based on CDIO concept.

Table 3.0 shows the summarization of activities conducted in Project I and II as discussed in section 5. The summarization is based on the main activities correspond to CDIO (Conceive- Design- Implement- Operate) stages. Table 3.0 shows all the 4 stages in CDIO (Conceive, Design, and Operate) listed and relates it to activities conduct in Project I and II. The first Stage of CDIO, Conceived is coordinated with the activities conducted in Project I and II such as Literature study, brainstorming, discussion and further research. The purpose is to identify and select the project that are relevant and suitable to group persona and most importantly comply with the values or criteria set by group as well as assemble to the curriculum requirement. This stage is very crucial and if not properly discussed and brainstormed while selecting the project title it may delay the whole project and students are unable to complete their project within the time allocated. After the title was select further research need to be done to furbish the design process as stipulated in the second stage of CDIO. Hence conceive on this initial stage of CDIO involves defining the needs and problems to be solved and technology required, considering the enterprise strategy and regulations resembled to the listed activities.

Table 3.0 Summarization of Activities in Project I and II

Stage	Cdio Item	main Activiti (OBE)	Activities
1.	**Concieve**	***Project selection***	• Literature study • Brainstorming • Discussion for Select title • Research
2.	**Design**	***Project Planning and Design***	• Prepare action plan (identify activities) • Design hardware and software (control algorithm)
3.	**Implemet**	***Project implementation***	• Build the project (hardware and software) • Testing & Troubleshooting • Modified • Validate
4.	**Operate**	***Project demonstration and presentation***	• Demonstrate • Present & exhibit • Report writing/documentat ion

During the design process (stage 2 of CDIO), for a project I and II, the activity is to prepare an action plan and design of hardware and software (control algorithm). At this stage the group members will identify what activities should be conducted along the two semesters' time frame. Gantt chart will be employed to execute the project. Another activity needed to be conducted during this stage is creating the design of hardware and software algorithm such as drawing electrical schematic diagram and flowchart algorithm program. This design stage is an initial technical task to be conducted, but this activity may be repeated again after the implementation stage in stage three of the CDIO. At the design stage it is very important for students to focus and concentrate on their activities. Indeed, they need to be innovative and creative to produce better quality with low cost project. The third stage of the CDIO is implementing. In this stage, students need to install component, solder, create program coding, compile and download in to project (micro controller chip), testing, trouble shooting and circuit modification if necessary. These activities involve a lot of technical skills and time. Therefore, once the implementation stage is completed and if the project is functioning well, it usually will be a moment of joy for students. This feeling will motivate and engage students to explore more projects in future. Students will be able to explore the project with their own knowledge and experience. The last stage of CDIO approach is Operate. In Project I and II the actionable conduct in this stage is to demonstrate the final project and present it to the supervisor and panel. Lastly is the report writing and submission to the supervisor.

The activities conducted implies that students are able to develop the personal, interpersonal, teamwork, communication skills and professional skills in the early stage of the project I and II through activities such as literature study, brainstorming, discussion and further research as stated in conceiving stage of the CDIO. Innovative, creative, analysis, synthesis, engineering reasoning and problem solving skills and evaluation takes place in the middle and final stage, the design, implementation and operate are in stage 2, 3 and 4 of CDIO.

Activities conducted in Project I and II as discussed above are the process conducted by students to produce final product or project. The validation process shown that the activities conducted are corresponding to the 4 stages of CDIO approach. This indicates that the learning activities and approach in Project I and II as adopted by OBE curriculum is complying to the CDIO approached as well as real life of engineering scenario practice in industry.

7. Conclusion

The CDIO initiative is to expose students with a wide variety of personal, interpersonal and system building skills that will allow them to deal with real world engineering problems. The attempt made to address this issue in Malaysia Polytechnics through the evaluation process made based on OBE approached in Project I and II shows that it is corresponding to the four (4) stages in CDIO concept. The above case study also shows that the activities in Project I and II is a comprehensive set in acquire knowledge, skills and attitudes as set by OBE curriculum. However, in the context of the CDIO approached, the activities in Project I and II are not clearly stated in the curriculum as a CDIO learning domain. Therefore, the CDIO learning domain should be holistically included in a project I and II curriculum as the engineering process in problem solving and related skill is practiced in industry as ‘learning to do – Conceive Design, Implement and Operate. Moreover, not all activities in other courses in Electrical Engineering are similar with activities in Project I and II. Hence, it is suggested that Polytechnic should integrate the CDIO and OBE concept into all their engineering curriculum frameworks. This means that, in order to improve the OBE curriculum, the CDIO concepts in polytechnic curriculum are essential. Indeed, the combination of CDIO and OBE concepts in curriculum will be a value added skills to Malaysian polytechnic graduates. As a consequence, employment rate amongst the Malaysia Polytechnic graduate will improve gradually. The use of the CDIO concept in polytechnic curriculum is now ready to be implemented and promote to ensure an increase in employment rate amongst graduates and also to make known to state holder such as student, academic, accreditation board and industries. This will alert the industries that Malaysia Polytechnic is now producing the best quality graduate that suit to industry need.

References

Bai Jianfeng, Lei Hu, Yanfen Li, Zhen Tian, Lili Xie, Lijun Wang, Mingyuan Zhou, Jie Guan, Huaqing Xie, The progress of CDIO engineering education reform in several China universities: A review, 3rd World Conference on Learning, Teaching and Educational Leadership (WCLTA-2012), Pg 380-385

Dokument Kurikullum Diploma in Electronic Engineering (Computer, 2010), Jabatan Pengajian Politeknik , Kementerian Pengajian Tinggi Malaysia.

Hasbullah, S. Jariah, N. Aidi etl, (2011), Dokumen Prosedur Penilaian Kendiri Program Pengajian Politeknik, Jabatan Pengajian Politeknik, Kementerian Pengajian Tinggi, Edisi 1.

Jabar J. A. Lee M.F, (2011), Polytechnic OBE Training Module, Jabatan Pengajian Politeknik Malaysia, Kementerian Pengajian Tinggi Malaysia

Johan Malmqvist, Kristina Edström, Svante Gunnarsson & Sören Östlund, The application of CDIO Standards in the evaluation of Swedish engineering degree programmes, *World Transactions on Engineering and Technology Education © 2006 UICEE, Vol.5, No.2, 2006*

Kristina Edström and Anette Kolmos,(2012),Comparing Two Approaches For Engineering Education Development: Pbl And CDIO, *Proceedings of the 8th International CDIO Conference, Queensland University of Technology, Brisbane, July 1 - 4, 2012*

Malaysian Society for Engineering & Technology, 21st Century Professionals Newsletters, Issue Mar - Apr 2013

Muhamad Rumzi Bin Mamat, Mohamad Sattar Bin Rasul, Aidawati Binti Mustapha , Outcome-Based Education lmplementation in Malaysian Polytechnics, DIGES Politeknik Muazam, Bil. 4, 2013.

M. M. N. Megat Johari, A. A. Abang Abdullah, M. R. Osman, M. S. Sapuan,N. Mariun, M. S. Jaafar, A. H. Ghazali, H. Omar And M. Y. Rosnah A New Engineering Education Model for Malaysia, Int. J. Engng Ed. Vol. 18, No. 1, pp. 8±16, 2002

N. M. Nor1, N. Rajab and K.M. Ismail, Educating the Engineer of 2020: Malaysian Scenario, University Teknologi Malaysia / College of Science and Technology, Kuala Lumpur, Malaysia, http://www.ineer.org/events/icee2008/full_papers/full_paper291.pdf, retrieved 18 Feb 2015.

Nik Azida binti Abd Ghani, Tengku Ahmad Badrul Shah bin Raja Hussin, Muhammad Zubir bin Mohd Hanifah, Implementation of Students-Centred Learning among Malaysia Polytechnic Lecturesr, Proceeding of International Conference on Active Learning (ICAL 2012), Universiti Teknikal Melaka, ISBN NO. 978-967-0257-15-0, pg 20-23

Peng Lin, Yingzi Wang, Guangjing Xiong, Weikun Wu & Huiliang Huang, (*2006),* Adoption of CDIO elements in the final year civil engineering design project, *World Transactions on Engineering and Technology Education.*

Raymond Lynch, Niall Seery And Seamus Gordon, An Evaluation Of CDIO Approach To Engineering Education, Department Of Manufacturing & Operations Engineering, University Of Limerick, Ireland, http://doras.dcu.ie/447/1/Lynch-Seery-gordon_ISEE07.pdf., retrieved 18 Feb 2015

S.H. Pee, Helene Leong (2005), Implementing Project Based Learning Using CDIO Concepts, 1st Annual CDIO Conference, Queen's University Kingston, Ontario, Canada June 7 To 8.

Wong, Imrie & Xie (2008). *Problem Based Learning Applied to a New Unit of Study on Programmable Logic Design, AaeE Conference Proceedings*, Rockhampton, December 2008.

Yin kong, (2010), CDIO Concepts for Computer Engineering Teaching, Preceedings of 2010 AaeE Conference, Macquqrie University Sydney Australia. Pg91-97.*UICEE Vol.5, No.2.*

Zhou Nan-Zhao, Four 'Pillars of Learning' for the Reorientation and Reorganization of Curriculum: *Reflections and Discussions* http://www.ibe.unesco.org/cops/Competencies/PillarsLearningZhou.pdf/ retrieved 29 jun 2015