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Open Ended Laboratory (OEL): Associating Comprehensive Learning and Skills for Civil Engineering Student

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Abstract: An open-ended lab is where students are given the freedom to determine and do their own experiments, instead of merely following the already set guidelines from a lab manual or elsewhere. OEL is one of the approach in Outcome-Based Education (OBE) in a way to promotes students to be more comprehensive in all aspect in learning. This paper highlights the OEL processes framework as supporting documents to enhance OBE results towards sustainable development in education. This approach helps to systematically fasilitate students-centerd learning to improve, embeded and monitor all skills required by civil enginering students such as generic skills. In this paper, the focus of the Program Outcomes for this OEL approach, level of openess that reflect to the procedure in teaching in the labooratory, the used of rubric provided was discused and the comparison is made between traditional way of conducting and implement of laboratory with the OEL concept in order to get the overview of the performance of the OEL implementation.

Keywords: Comprehensive Learning, Open Ended Lab, Skills

1. Introduction

Starting in Semester I of the 2014/2015 academic session, Faculty of Civil Engineering (FCE) UiTM Pahang took an action to change all the delivery method of laboratory course from traditional way of teaching to an open-ended laboratory (OEL) style. This implementation was in agreement with both the Engineering Accreditation Coucil (EAC) and Accreditation Board for Engineering and Technology (ABET) (Tranquillo, 2006) for engineering accreditation criteria requirements. This approach had been taken out in order to prepared a students with the ability to design and conduct experiment as well as analysing and interpreting the data and also the ability of students to work in a group (Haron et al., 2013). To suit with their career as an engineer in future, their must be able to transform the knowledge from the laboratory works into a real cituation to make them better and talented engineer who are not only expert in theories but are also good in hand-on the laboratory works practically.

The typical conventional approach of conducting laboratory course normally conducted on a group of students running fixed experiment with provided laboratory manual that consist of all information starting from introduction, objective, procedures, until expected results. This types of approach is no longer suitable in the recent context of engineering education, especially in an outcome-based education (OBE) concept (Norliza et al., 2011). Students must be swich the mode to the active learning include open ended assignment and laboratory (Webb, 2007) and virtual laboratory (Domingues et al, 2010).

OEL is a one of the approach in OBE in a way promotes educatoors to be more comprehensive in all aspects of teaching and learning (Alias et al., 2012). The new curicular has been design in such way students be able to graps the affective and physomotor skills as well as acquired skills need in engineering industries. As time goes, the latest indicator tool in measure students performance is by implement integrated cummulative grade point average (iCGPA) in their study. The results will not longer display the grade gained during their study time, but also the skills achievements during the period of time. Most of the skills achievement in iCGPA can be polish and gained during OEL session.

1.1 Open Ended Approach

Recently there is an issue of the employability of an engineering graduated in Malaysia students from the engineering industry due to the lacking of skills in in order to get a job or to complete their tasks given. Skills such as teamworks, leadership and generic skill have become attributed of employers favour (Green et al., 2009). Unfortunately these skills are not easily imparted in an education curriculum since many academicians are not trained in these skills themselves. As OEL taking place in the curriculum, the challenges start on how to establish effective teaching and well-design assessment to develop highly competent engineer persons.

OEL as known as one part of engine that runs the OBE smoothly while in another side, OEL is also importance method in deliver Conceive-Design-Implement-Operate (CDIO) teaching padagogy. FCE UiTM Pahang took an proactive action in order to promotes educator to be more comprehensive in all aspects of teaching and learning. The implementation of OEL and CDIO based on OBE requirements in this faculty also emphasizes on educator's and student's reading role simultaneously, cultivates student's learning interest, thingking and practice their capabilities in analyzing and solving problems (Rahman et al., 2015).

The OEL implementation was mapped with the programme outcomes (POs) for diploma of civil engineering course (Table 1) in order to fulfill the requirement of EAC and MQA. Basically, POs is a part of OBE and divided into three types of domain for educational learning, cognitive domain, affective domain and psychomotor domain. The learning based on the examination pattern and physical involvement in the laboratory activities can be assessed for cognitive and psychomotor as a core domain compared to an affective domain. The affective domain describes learning objectives that emphasize a feeling tone, an 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. Regarding to this condition, the OEL skills consists of leadership, teamwork, and critical thinking was identified as a supporting document to assess an psychomotor domain skills (Rahman et al., 2015).

Table 1. 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. Application Rubrics for OEL Assessment

2.1 Procedure Teaching in the Classroom

The learning process in the classroom was started from delivering conceptual information and practically applied during laboratory session in order to fulfil course 's assessment itself at the end of semester. Normally, the students are working in a groups preferably not more than five in a group and each group was carried works during in-lab and out-lab session. In –lab session means students run the activities during laboratory class, while out-lab session is the discussion handled among team members outside class time (Haron et. al., 2013).

OEL encourage lecturers to facilitate and supervise students'activities in the laboratory class rather than teach or use traditional methods. This method was encouraged students to obtain extensive information from the library, journals and reports to research methods and findings as their oen references. Discussion during out-lab session was required the students to be more independent, more productive and brainstorm more ideas. In FCE UiTM Pahang, each group were required to execute an experimental works by starting with explaination an apparatus use for the topic given including the parameter that they can gathered from an experiments before operate the apparatus. It is due to their assessements were based on laboratory reports preparing in a group and individual attributes that represent their teamwoks skills, leadership and practical skills.

2.2 Level of Openness

In 2014, Arslan was defined openness as the degree to which the students make decisions about the problem, the procedure and or the answers in order to molding students to be more proactive, creative and innovative. In other words, they are required to determine the objectives and scope, identifying apparatus needed and preparing the methodology, running the experiment and finally submitting the reports. Oral presentation may be included. The Students should receive sufficient laboratory work to complement engineering theory that is learnt through lecturers.

According to whether the lecturer prescribes the problem, the apparatus to be used, the procedure to be followed and the expected answer, or the students are required to make these decisions for themselves, a scale of openness to inquiry has been developed to classify laboratory activity (Kılınc, 2007). The scale was first formed by Schwab and then four-level categorization was described by Herron (Smithenry, 2010). In the first level, confirmation inquiry; a question and a procedure which to answer it are given to students, they follow the procedure and confirm an answer which they knew beforehand. In the second level, structured inquiry; a question, a problem or and an outline are provided by teachers, but students do not know their answers (Smithenry, 2010). In the third level, guided inquiry; the problem is given to students, but they are self-directed in terms of designing procedure and exploring the answers (Smithenry, 2010). In the fourth level, open inquiry; students formulate the complete project; they develop a question, identify what must be known, design their own experiments, interpret results, and evaluate reliability and validity of the study (Smithenry, 2010). It should be understood that all inquiry levels are not same and equal.

Comparing to the traditional approaches, the students solely responsible to follow a very prescriptive format, often working to verify what is already known, as opposed to undertaking true experimentation. Many lecturers and researchers today are calling for a more open and investigative approach to student experimentation. So, nowadays FCE preparing the table of level of openness for all branches Diploma in Civil Engineering to standardize the delivering approaches among the lecturers and students as shown in Table 2. In this table, the degree of openness was fixed to the level of openness in an experiment with details description for each format that required fulfilling in the reports.

Table 2. Level of Laboratory Openness applied in FCE, UiTM Pahang

LEVEL	PREAMBLE	PROBLEM	WAYS & MEANS	ANSWERS	COMMON NAME	DEGREE OF OPENESS
O	Given	Given	Given	Given	Traditional	0%
1	Given	Given	Given	Open	Partially Open	33%
2	Given	Given	Open	Open	Partially Open	66%
3	Given	Open	Open	Open	Fully Open	100%

A good practice is the capabilities of lecturers for preparing the different level of openness for each topics consist in the laboratory courses and it can be rotate at least 6 cycle CQI to obtained an accurate results and definitely as supporting document in monitoring COs and POs' achievement.

2.3 Rubrics

The student achievement are graded based on the originality of their idea, results and discussion from the laboratory assignment, tasks and tests. In FCE, UiTM Pahang, the laboratory works was applied to increasing emphasis on student centred learning and the importance of developing investigation and problem-solving skills there is value in reflecting type of laboratory work that is carried out in the curriculum program.

As a practices in our FCE UiTM Pahang, an experiments were conducted in the control group over a 14 weeks period and two practical tests as an individual formative assessment. Mostly the contribution marks was setup with 30% from practical tests, 10% from weekly reports and remain marks should be assessed from the final examination. The overall marks for the experiment were obtained by taking into consideration the rating given for the laboratory report, and practical and teamwork skills. The result of assessment of COs and POs will then be used to consider the Continuous Quality Improvement (CQI) recommendations.

Using the master rubrics for practical test (Table 3), lecturers incharge for each course are compulsory to prepare the different rubrics every semester along with the questions for practical tests. The rubrics was standardize as a formative assessment for learning emphasises enhancing the process of learning instead of just assessinfg the level of students' competence.

Table 3. Master Rubrics Practical Test

NO	QUESTION	RUBRIC SCALE						TOTAL
		0	1	2	3	4	5	
1	Question related to safety	Unable to answer/explain	Able to answer/explain					1
2	Question related to safety	Unable to answer/explain	Able to answer/explain					1
3	What is/are the objective(s) of........?	Unable to answer/explain	Able to answer/explain but inaccurate	Able to answer accurately				2
4	What is/are the apparatus/machine(s) required to conduct the study/laboratory test?	Unable to answer/explain	Able to answer/explain but inaccurate	Able to answer accurately				2
5	How to set-up the study/laboratory test (preliminary stage)?	Unable to answer/explain	Able to answer/explain but inaccurate	Able to answer accurately				2
6	Demonstrate on how to use the apparatus/machines. How to run the study/laboratory work? (Note: Student must demonstrate and explain all the steps accordingly)	Failed(0-10%)to demonstrate and conduct the apparatus/machine (Take more than 10 minutes to set-up)	Unable(11-30%) to demonstrate and conduct the apparatus/machine but fail to follow all procedure (missed almost all steps)	Able(31-50%)to demonstrate and conduct the apparatus/machine but fail to follow all procedure (lacking)	Able (51-70%)to demonstrate and conduct the apparatus/machine as procedure (lacking)	Able(71-90%)to demonstrate and conduct the apparatus/machine as procedure (missed few steps)	Able(91-100%) to demonstrate and conduct the apparatus/machine successfully as procedure	5
7	Result & analysis (type, data presentation/formula/method etc)	Unable to answer/explain	Able to answer/explain but inaccurate	Able to answer accurately				2
						TOTAL MARKS		15

3. Comparison Between Traditional Method (TM) and Open Ended Laboratory (OEL)

Table 4. Comparison of Traditional Method (TM) and Open Ended Laboratory (OEL) (Bolong et al., 2014, Chiu & Chiu, 2004 and Haron et al., 2013)

Traditional Method (TM)	Open Ended Laboratory (OEL)
Expository (Cook book) based with known outcomes	Problem based with many possible outcomes
Students may not understand the theory of the experiments	Students understand the theory and procedure since they have to find it themselves
Each group of students are doing the same experiment	Each group of students will design their own experiment within the given scope
Limit students creativity in problem solving strategy	Students are more creative in solving the problem
Does not simulate real problems	Simulate the real problems
Marks are based on students laboratory reports, practical tests and final examination	Marks are based on students laboratory reports, soft skill (teamwork), practical tests and final examination
Teacher centered learning	Student centered learning

Table 4 summarize the comparison between Traditional Method (TM) and Open Ended Laboratory (OEL). The TM use expository style teaching where the experiments are conducted by referring to the laboratory manual (Bolong et al., 2014). Therefore, students are already expected the outcomes of the experiments. Meanwhile, OEL used problem based style where it generates many possible outcomes. Students will then using their own analysing skills to intepret the outcomes. Next, students can perform the experiments eventhough they did not understand the theory of the experiments using TM (Chiu & Chiu, 2004). This is bacause they can just follow the steps from the laboratory manual. This differs with OEL where the students need to find all of information about the experiment beforehand. This at the same time will greatly improve their lifelong learning skills (Bolong et al., 2014).

Apart from that, each group of students will conduct the same experiment in TM while in OEL, Each group of students will conduct the same experiment but with different approach based on their research design (Chiu & Chiu, 2004). Thus, it will involves greater creativity in solving the problem compared to TM. Furthermore, using OEL is far more practical because it simulate the real problems facing by the industry (Haron et al., 2013). This will give an exposure for the students before working in the real environment. Besides that, The assessment of OEL includes teamworking where the students involment during the experiment was taken into account. This to make sure that each group members gives full commitment during the laboratory session. Lastly, OEL is more directed toward student centered learning compared to TM. This is because the majority of tasks rest in the students shoulders. The instructor will acts as a facilitator during the experiment.

Eventhough OEL seems an ideal method in enhancing students understanding of laboratory experiments, there are some downsides in this method expecially towards students and lecturers. The laboratory work will increase the burden for students to spend more time in designing proper experimentation program before conducting the experiment(Chiu & Chiu, 2004). This will greatly increase their Student Learning Time (SLT) and that might affect the SLT for other subjects. Futhermore, it is also increase the burden for lecturers in assessing the students laboratory reports because each group execute different experiment to solve the problems. Apart from that, laboratory technician must arrange and assemble the suitable laboratory materials and instruments for the students in order for them to conduct the experiments based on their experimental design. This will be a problem if the required materials are hard to obtained or the laboratory instruments are limited. Lastly, the laboratory time taken for students conducting the experiments usually longer than TM. Student needs to run the experiment during the night or in the weekends.

4. Conclusion

This paper explains the concept of open ended laboratory, its applications, comparison between open ended laboratory and and traditional method as well as the drawbacks of adopting this pedagogy. OEL is a new method of teaching that supports the CDIO and OBE requirements. The concept is more towards the student centered learning which required them to design their own experimental programme themselves. The levels of laboratory experiments are divided into four difficulty ranging from zero (easy) to four (hard). The rubrics for assessing the students laboratory report are changed based on the level of difficulty for each semester.

While the concept seems promising in enhancing the students learning capbilities, further research needs to be done to prove its effectiveness. This includes investigation on the students performace between open ended laboratory and traditional method, students learning time as well as students and leacturers perception with regards to the implementation of this pedagogy.

5. References

Alias, A, Nor, N. A. M., Latib, F. W. M., & Bhkari, N. M. (2012). Project Based Laerning via Open Ended Projects: Approach of Comprehensive Learning and Skills Development in Civil Engineering Laboratory. Konferensi Akademik (*KONAKA 2012)*, 391- 397.

Bolong, N., Makinda, J., & Saad, I. (2014). Effect of Open-Ended Laboratory toward Learners Performance in Environmental Engineering Course: Case Study of Civil Engineering at Universiti Malaysia Sabah. *International Journal of Social, Behavioral, Educational, Economic, Business and Industrial Enginering, 8* (8), 2554-2558.

Chiu, D. M., & Chiu, S.Y. (2004). An Open-Ended Laboratory System with Computer-aided Simulation for Undergraduate Electronic Engineering. *International Journal Engineering Education, 20*(2), 193-197.

Domingues, L., Rocha, I., Daurado, F., Alves, M., & Ferreira, E.C. (2010). Virtual lab in (bio) chemical engineering education. *Education for Chemical Engineer,* 55 – 71.

Green, W., Hammer, S., & Star, C. (2009). Facing up to the challenge : Why it is so hard to develop graduate attributes?. *Higher Education Research & Development 28*(1), 17-19.

Haron, Z., Mohammad, S., Sam, A. R. M., Mustaffar, M., & Yatim, J. M. (2013). The Implementation of an Open-Ended Experiment in Civil Engineering Laboratory. *Procedia-Social and Behavioral Sciences 102*: 548 – 559.

Norliza, A. R., Noorhisham, T. K., Sobri, M. T., & Siti Rozaimah, S.A. (2011). Comparative Study Between Open Ended Laboratory and Traditional Laboratory. *IEEE EDUCON Education Engineering 2011-Learing Environments and Ecosystem in Engineering Education,* 1-5.

Rahman, N. A. A., Ismail, M. I., & Muda, M. F. (2015). Enhancement OBE Performance for Civil Engineering Students with CDIO Implementation. *Konferensi Akademik (KONAKA 2015)*, 204-212.

Webb, C. (2007). Assessor Report for Biochemical Engineering Programme (Department of Chemical & Process Engineering, Faculty of Engineering & Built Environment, Universiti Kebangsaan Malaysia).

Arslan, A. (2014). Transition Between Open and Guided Inquiry Instruction. *Procedia Social and Behavioral Sciences 141 (25)*, 407-412.

Kilinc, A. (2007). The opinion of Turkish High School Pupils on Inquiry based Laboratory Activities. *Journal of Educational Technology 6*(4), 56-72.

Smithenry, D.W. (2010). Integrating Guided Inquiry into a Traditional Chemistry Curricular Framework. *International Journal of Science Education 32* (13), 1689-1714.