Project Based Learning via Open Ended Projects: Approach of Comprehensive Learning and Skills Development in Civil Engineering Laboratory

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ABSTRACT

The approach in Outcome-Based Education (OBE) in a way promotes educators to be more comprehensive in all aspect in teaching and learning. This trend is to create a balance between technical and non-technical aspects in the training and education of engineers. The shift has been shown in engineering education and curricula design worldwide. The new curricular has been designed in such way students be able to grasp the cognitive part in their learning as well as acquired skills needed in engineering industry. The challenges are to establish effective teaching and well-designed assessment to develop highly competent technical persons as well as social skills. It is ideally to nurture students' skill in analytical, logical, organized and structured thinking stems. However, all engineering schools in Malaysia have adapted OBE of the new higher learning education thus need to enhance people skills in conceptual and holistic thinking. The literature section will cover all aspects that concern OBE, co-operative learning, project based learning and assessment. This paper examines the effectiveness of well- design assessment and students' perception for open ended project. Using cluster sampling, students are selected from semester 4 and analyzed based on given questionnaire. The data shows students agree that there is significant course outcomes achievement by using open ended project and incorporated with conceive – design – implement – operate (CDIO) method.

Keywords: *project based learning, open-ended, comprehensive learning, skills development*

Introduction

The approach in Outcome-Based Education (OBE) in a way promotes educators to be more comprehensive in all aspects of teaching and learning. As stated by Horak (2003) it is a trend to create a balance between technical and non-technical aspects in the training and education of engineers. The shift has been shown in engineering education and curricula design worldwide. The new curricular has been designed in such way students be able to grasp the cognitive part in their learning as well as acquired skills needed in engineering industry.

The challenges are to establish effective teaching and well-design assessments to develop highly competent technical persons as well as social skills. It is ideally to nurture students' skill in analytical, logical, organized and structured thinking stems. However, all engineering school in Malaysia have adapted OBE of the new higher learning education thus need to enhance people skills in conceptual and holistic thinking. The literature section will cover all aspect that concern in OBE, co-operative learning, project based learning and assessment.

OBE Initiate Co-operative and Project Based Learning (PjBL)

OBE creates multi-level learning opportunity for educators and learners perspective. The paradigm has been shifted from conventional towards OBE approach as concluded in Table 1.

Table 1: The Differences of Pre-descriptive and Outcome-Based Education (Asmidar & Norshariza, 2007)

Pre-descriptive	Outcome-Based Education
Curricula and courses emphasize content.	Curricula and courses balance content, skills and attitudes (i.e traditional content; critical and creative thinking; problem solving, problem formulation; teamwork, communication; ethical, professional considerations).
Fundamentals applications "trust me".	Integrated – introduce engineering problems and projects; bring in basic science and mathematics in the context of the problems and projects.
Content determined by syllabus. ("I will cover…")	Content determined by learning objectives. ("The students will be able to…")
Teaching style addresses only one learning style.	Teaching style addresses spectrum of learning styles (visual/verbal, concrete/abstract, active/reflective, sequential/global).
Except in labs, most in-class activity done by instructor (lecturing, occasionally asking question).	In all classes, burden of activity shared by instructor and students (discussing, explaining, brainstorming, questioning, reflecting, using computers).
In course assessment, students do not know the criteria being assess (no transparent between lecturer and student); and students do not understand the criteria being assess.	The course assessment must be an open process (transparent); should be valid; need to be reliable, need to be fair; and should be an integral component of course design.
The approach to assessment remains conservative through ignorance.	Results from assessment processes need to be applied for continuous improvement of student learning outcomes and program effectiveness. Always alert on quality of graduates (include close-loop of program assessment process).
Wide variations in marking between modules and assessors.	Frames and reference which lecturers bring to assessment are systematic and standard.
Absence of well defined criteria so consistency is difficult to achieve. Criteria used between subjects, within subject, between institutions and within institutions are not consistent.	A shift in focus – the greater focus on outcomes criteria and course objectives. Establishing and measuring them by said of stakeholders. All the outcome criteria – course objective are mentioned and documented to avoid inconsistency.

The academic freedom given in learning styles, delivery and assessment serve greater opportunity to explore various methods to achieve designated course outcomes (COs) and programme outcomes (POs). Thus enable educators to visit the latest approach in OBE which is known as CDIO. The CDIO initiative known as Conceive-Design-Implement-Operate (CDIO) described as the current reforms in higher engineering education (Mbanguta, 2003).

Mbanguta (2003) suggested a general profile for a good engineer in the learning society of the new millennium is built on the ability and willingness to learn, on solid knowledge of the basic natural sciences, and on good knowledge of some field of technology. Other skills include general human values and the communication and leadership capacities needed in modern working life. As agreed by Varin (1999), the engineering graduates in a modern society must be able and willing to learn, have solid basic knowledge of their major technical discipline, have commitment to quality, have internationalization-oriented skills, have good commucations skills, be able to work in a team, be able to lead and manage resources, demonstrate professional and ethical responsibility and be able to deal with uncertainty and ambiguity. The discussion from Mbanguta (2003) stated that CDIO has four themes:

1. Engineering education reform must first take place in the CDIO skills-based curriculum, which is underpinned by a deeper working knowledge of technical fundamentals. This will ensure that it addresses the necessary material and appropriate to conceive and build successful systems and products.
2. An improved pedagogy, which takes into account the students' prior experience and its effects on learning, must complement the new curriculum. The CDIO initiative seeks to increase active and hand-on learning, emphasis problem formulation and solution, and increase the emphasis on concept learning and the enhancement of learning feedback mechanisms.

3. It has been recognized that the key to educational improvement is the development of an effective assessment scheme, so that the progress of students and any improvement in the quality of the education provided can be tracked.

4. In the CDIO initiative it is required to design and build products and systems to enhance integrated theory-practice or knowledge-application concept. Modern engineering workshops or laboratories that are conducive to this approach must therefore be developed.

Applying this new initiative in OBE, Faculty of Civil Engineering manages to design laboratory courses to suit for CDIO concept. The course assessment implemented by using open ended project in soil laboratory courses (ECG213).

Open Ended Project in Soil Laboratory Courses (ECG213)

The course, Soil Engineering Laboratory ECG223 is offered for Year II candidates which is part four of a civil engineering diploma programmed. This course is one credit hour with three course outcomes; (i) organize standard laboratory testing, (ii) conduct experiment and interpret data for report, (iii) perform effectively as a team in carrying out the laboratory works. In this course too, student are not just to be evaluated on the technical assessment based on the output while they will also be evaluated on the soft skill on the performance during the PjBL. The class is divided into team consisting of 4 or 5 people. These teams are assigned to do 4 different laboratory sessions which each session meets 2 hour per week and assigned task to be completed in 4 weeks duration of time.

Project Briefing

Earlier of the semester, students are supplied with a problem statement and marking rubric for the PjBL. Lecturer will brief to the class based on what students should do during this 4 weeks project. The location of the soil sample must be around the UiTM Pahang area only. The soil sample outside this area is not accepted at all. Student must collect at least 3 kg soil sample with soil depth should at least 500mm depth. Four different laboratory works need to be completed which are moisture content, sieve analysis, cone penetration and particle density test. As we know the time frame of this project is 4 weeks and students need to complete 4 different laboratory session and write report in this duration and submit the completed laboratory report to the respective lecturer. Late submission will be penalized mandatoraly. In order to make sure all the students will submit the best report, this project also provides marking rubric. When writing the report, student can refer to this rubric to make sure all the important and relevant document are attached together.

Routines and Tasks

In this PjBL, students need to finish 2 stages which cover stage 1; assess student's ability to collect disturbed sample at UiTM Pahang area and conduct laboratory testing to clarify the soil classification and properties. At this stage, student must choose the site location and give a detailed location with explanation based on map of UiTM Pahang, sketch the location with appropriate standard technical drawing, take a photograph of the site and students must describe the location based on observed site terrain, its surrounding condition features and etc.

While dealing with the collection of disturbed samples, students are given order to take soil sample with soil depth at least 500mm depth and collect at least 3kg sample. This soil sample will be left exposed to room temperature about 24 hour or more. After that, sample will undergo 4 different laboratory works which are moisture content, sieve analysis, cone penetration and particle density test. All the equipment for these labs are provided at Soil Engineering Laboratory and at the end of each session of lab, the data should be checked by lecturer or laboratory technical officer to make sure the data collection is accepted and correct.

The Report Writing

Second stage of this PjBL is to assess student's competency in analyzing and interpreting laboratory data thus report all information in standard format. Each group of students must put all the important part such as abstract, introduction, methodology, result, discussion, conclusion, references based on APA style, appendix like photos, specified or relevant standard and etc. Late submission of this report will be penalized thus will affect the students soft skill performance mark.

Assessment

The assessment strategy for open-ended project is to align with the CO and PO. However the COs are not categorized in the same domain. At this stage, instructor need to design tasks that can deliver the outcomes. Domain that dominant for those particular outcomes is identified. CO1 and CO2 are classified in cognitive domain and CO3 is to cater affective domain. Table 2 is the assessment strategy extracted from course information.

Table 2: Assessment Strategy for ECG223

Course Outcome	PO3	PO5	Assessment
CO1 - Organize standard laboratory testing		√	• Lab report • Test
CO2 - Conduct experiment and interpret data for report	√		• Lab report • Test
CO3 - Perform effectively as a team in carrying out the laboratory works.		√	• Lab report • Test
PO3: Ability to function effectively as an individual and in a group with the capacity to be a leader or manager or as well as an effective team member PO5: Ability to supervise and function as a team member and have entrepreneurial capabilities			

This information is needed to design a comprehensive open-ended project question. The question has been set with two major tasks that state clearly the objectives and the activities need to be executed. The first stage is to assess students' ability to collect disturbed samples and conduct laboratory testing to clarify the soil classification and properties. The scope involved sub-soil exploration and testing. The second stage of this test is to assess students' competency in analyzing and interpreting lab data thus report all information in standard format.

The question is attached with set of rubrics for the assessment. The rubrics also act to detail all requirement needed before submission. This practice is to promote transparent and necessary guidance for students to plan their work in laboratory and report writing. Three major themes are identified which describe as description on preliminary data on site and available resources, conducting experiment and teamwork and management.

1. Description on preliminary data

Students are trained to be able to search data based on available data whether on-line or from relevant department. This is essential to introduced students on the importance of having desk study before executing any site works. The data collection is to include maps, drawings, details of existing or historic development, geological maps and sketching. Students with good insight will explore relevant standards to describe as referred to BS5930.

2. Conducting experiments

All criteria in this section also act as guidance for students to train their data management skills. The orders are as follows: structured data management skills by using appropriate tables and templates, quality control (all data need to be checked by instructors), analyze raw data to obtain the objective of the experiments and summarize the calculated data.

3. Teamwork and management

Teamwork and management criteria are solely depending on report which is the end product for all activities in this project-based learning. The criteria details are time for submission, formatting, editing and referencing. Ability to produce complete report with all requirement set in the question will reflect how well they can work in group. Flow chart in Figure 1 describes the whole process undertaken by students and monitoring stages needed for lecturer or laboratory supervisor.

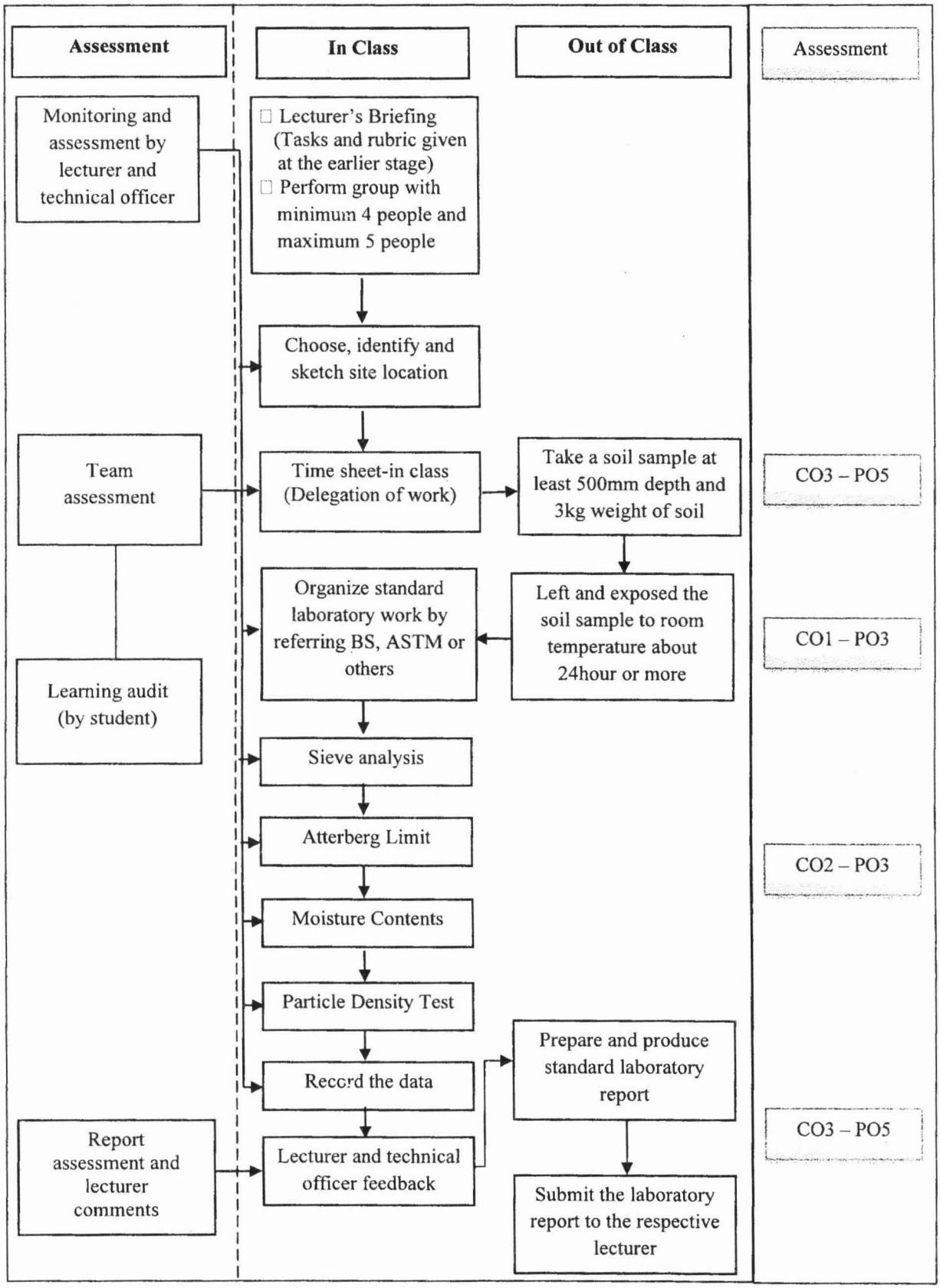

Figure 1: The processes Involved in Open Ended Laboratory Assessment for Soil Engineering Course (ECG213)

Skills Development in Soil Engineering Laboratory (ECG223)

Table 3 shows the result based on a survey conducted for 36 numbers of students. The sample is taken from cluster sampling to ask students perception on open ended test. The questions rating to maximum level 4, which from strangle disagree – 1, disagree – 2, agree – 3 and strongly agree 4. This data can be used as the baseline for the next research.

Table 3: Students' Perception in Acquiring Skills from the Offered Course

Course Outcome	Students' Learning Experience	Related Programme Outcome	Mean Value	Standard Deviation
CO1: Organize standard soil laboratory testing.	I can analyse raw, interpret and observe data pattern for the use of soil engineering design	PO3	3.286	0.458
CO2: Conduct experiments and interpret data for laboratory report.	I can execute soil engineering testing (i.e.: sieve analysis, permeability, shear box, tri-axial and CBR tests)	PO3	3.472	0.506
	I can conduct field testing to determine soil bearing capacity and strength by using JKR Probe, Vane Shear and Sand Replacement Method		3.472	0.506
	I know the importance to refer to relevant standards (i.e.: British Standard, ASTM) as references		3.111	0.523
	I am able to produce standard report which detail in objective, procedure, well recorded raw data, analysis, interpretation and conclusion		3.500	0.507
CO3: Perform effectively as a team in carrying out the laboratory works.	I am able to work in a team effectively by participating actively in laboratory works and report writing	PO5	3.667	0.478
	I am able to practice my leadership skills in managing team members to execute laboratory works and report		3.639	0.487

Note: PO3 is an ability to identify, formulate and solve engineering problems; PO5 is an ability to supervise and function as a team member.

Most of the course outcomes show significant achievement (mean value at 3.47 – 3.67), while students' rate good understanding on how to use relevant standard (3.111). It is understood that standard provides a comprehensive guide and students have difficulties to understand the complex language. Students' mean value for CO1 is 3.286 that show they need guidance to help them to interpret data pattern based on laboratory analysis. Thus, strengthen in theoretical class is needed or collective discussion after laboratory hours will very much help.

Conclusion

The challenge in this new approach is to design an assessment that can developed students skills in multiple way. The instructor must have a good understanding on the subject, student population, outcomes requirement, and availability of materials, support staff and machines. It is understood that students still have difficulties to manage as they need to master the theoretical part of the subjects, have a good communication with team members, have a good time management skill, understanding standard guideline to support the data collected during experimental programme, and the others. However based on preliminary research, students agree this type of assessment is beneficial to grasp designed course outcomes.

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