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Research paper

Evaluation of students learning outcomes on engineering surveying

Goh Boon Hoe [1] *, Chiang Choon Lai [1], Betsy Lee Guat Poh [1], Kasturi Muthoosamy [1]

[1] Faculty of Science and Engineering, The University of Nottingham Malaysia, Jalan Broga, 43500 Semenyih, Malaysia
**Corresponding author E-mail: Boon-Hoe.Goh@nottingham.edu.my*

Abstract

Outcomes Based-Education (OBE) is a learning approach that cultivates student centered learning and emphasises on students' attributes, and it is becoming the mutual agreement by the signatory countries of Washington Accord 1989 to embed the OBE into their engineering education system. The implementation of OBE in an accredited engineering degree involves the design of OBE curriculum by setting the Programme Education Objectives (PEOs), Programme Outcomes (POs) and Module Learning Outcomes (MLOs), and measurement of the attainment of POs and MLOs. This paper presents the evaluation and attainment of POs on Engineering Surveying via Survey Field Course, based on students' self-evaluation approach, before-and-after attending the course. Five programme outcomes as required by Board of Engineers Malaysia were evaluated and the study revealed that only two programme outcomes (communication, and individual and team work) were not attained and need attention for future improvements.

Keywords: *Engineering Education; Engineering Surveying; Outcomes Based-Education (OBE); Teaching and Learning.*

1. Introduction

Washington Accord 1989 is an international agreement responsible for engineering degree programmes accreditation. Hence, signatory countries will mutually recognised the engineering graduate programme as an accredited programme that has met the academic requirements for entry to the practice of engineering. Malaysia as one of the signatory members, presented by Board of Engineers Malaysia (BEM) administrates the process of accreditation of engineering programme. The procedure is aligned with the standard of Washington Accord 1989 in which the endorsement of engineering education system is embedded with the Outcome Based-Education (OBE) [1]. Presently, this is a mandatory requirement for all higher education institutions in Malaysia that are offering engineering undergraduate programmes, as the pre-requisite of BEM accreditation.

OBE is a learning approach that cultivates student centred learning and emphasises on students' attributes (or outcomes). The implementation of OBE in an accredited engineering degree involves the design of OBE curriculum which includes the Programme Education Objectives (PEOs), Programme Outcomes (POs) and Module Learning Outcomes (MLOs).

To measure the attainment of POs, MLOs of each module should be mapped with POs and eventually the MLOs of individual module would be contributed to the accomplishment of POs. At module level, instructor is expected to design appropriate assessments in order to evaluate students' achievement on their MLOs. Meanwhile, the attainment of MLOs for each module would be recorded as an input for the cohort level to measure the overall POs achievement. This is the final stage to measure the student's attainment of POs upon graduation. The assessment of MLOs attainment is either in the form of summative or formative. Summative assessments evaluates students' learning and skills acquisition at the end period of a module. Examples of summative assessments are final year project, midterm test and final examination. Many studies have shown preference for summative assessment to evaluate MLOs [2], [3], [4]. However, a combination of formative and summative assessments is another alternative mode to assess MLOs that has been reported in many studies [2], [5], [6], [8]. Formative assessments monitor students' learning progress in a module and the assessments are in the forms of quizzes, on-going assignments (course works), project presentation, etc. Both the assessments provide data on students 'overall performances that reflect on their MLOs achievement. Nevertheless, some studies prefer using students' perception as feedbacks to identify students' attributes [2], [9].

Students' perception and feedbacks were found to be effective in the Continuous Quality Improvement (CQI) Cycle of engineering education [10]. Students are the main stakeholders in OBE learning environment and their inputs are essential for quality education improvement, and hence many studies have emphasised on students input for CQI [2], [10], [11].Students' feedback provide additional information of their MLOs achievement and the, deficiency of MLOs could be triangulated and identified for teaching improvement.

The objective of this study is to measure the attainment of POs on Engineering Surveying at module level, based on students' self-evaluation approach.

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2. Methods

2.1. Survey field course

Survey Field Course (SFC) is a compulsory course that is offered in first year of Civil Engineering undergraduate degree (Both BEng and MEng). During the six-day course, students are required to conduct actual surveying based on the project requirements and specifications in a group of six to seven students, supervised by academicians. In this course, students are required to work as a team to complete two major activities, i.e., setting-out the design points and conducts topographic survey with detailed engineering features, within a given timeframe.

2.2. Module learning outcome (MLO) mapping to programme outcomes (PO)

This study is focused on evaluation of MLOs and POs at module level; hence the module learning outcomes (MLOs) for SFC are as follows:

i) MLO1: On successful completion of this module, students will be able to setup and operate common survey equipment correctly
ii) MLO2: On successful completion of this module, students will be able to demonstrate how to carry out appropriate survey calculations;
iii) MLO3: On successful completion of this module, students will be able to identify problems and sources of error in survey observations; and
iv) MLO4: On successful completion of this module, students will be able to demonstrate the ability to work as part of a team.

Table 1: Mapping of SFC-MLO with PO

BEM-EAC Programme Outcomes	Module Learning Outcomes MLO1	MLO2	MLO3	MLO4
PO1	1	3		
PO2		1	3	
PO3		1	1	
PO4			1	
PO5	3			
PO6				
PO7				
PO8				1
PO9				2
PO10				3
PO11				
PO12				

The associated MLOs are mapped against POs of Civil Engineering Undergraduate Degree programme and the levels of association are rated as 3 (PO with measurement), 2 (PO with partial measurement) and 1 (PO with no measurement). According to BEM requirements [12], engineering graduates are expected to attain the 12 POs. However, the measurements of attainment for this module are PO1, PO2, PO5, PO9 and PO10, and each is defined as follows;

i) PO1: Engineering Knowledge - Apply knowledge of mathematics, science, engineering fundamentals and engineering specialisation to the solution of complex engineering problems;
ii) PO2: Problem Analysis - Identify, formulate, research literature and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences;
iii) PO5: Modern Tool Usage - Create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering activities, with an understanding of the limitations;
iv) PO9: Communication - Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions; and
v) PO10: Individual and Team Work - Function effectively as an individual, and as a member or leader in diverse teams and in multidisciplinary settings.

2.3. Questionnaire development

The questionnaire was designed to measure the attainment of learning outcomes and achievements of POs in Engineering Surveying subject. It has been reviewed by a few experts in the field of Civil Engineering for clarity of instructions, completeness of alternatives, and the use of appropriate language and terms. A trial version of the questionnaire was printed and distributed to 10 students to pre-test the questionnaire and for data reduction process. Minor amendments were made to the questionnaire after receiving feedback from the trial students.
The final version of questionnaire consists of four parts, which are designed to suit the measurement of the five POs. The first part is demographic questions, which would provide a comprehensive profile of each respondent (i.e. programme, current year, campus, etc.).
The second part request respondents to provide their opinion about statements related to their experiences in the survey field course, ranging from '1 = no understanding' to '5 = exceptional understanding'. Assessment on students' perception on their level of knowledge on engineering fundamental, problem analysis, modern tools usage, individual and teamwork, and communication are embedded into the questionnaire.
In the third part of the questionnaire, students are required to evaluate their skill level in the survey field course, on a scale ranging from '1 = insufficient skill' to '5 = exceptional skill'. Assessment on students' perception on their skill level on engineering fundamental, problem analysis, modern tools usage, individual and teamwork, and communication are embedded into the questionnaire as well.
The purpose of part 2 and part 3 is to examine on how the students are undertaking a range of tasks associated with the project before and after completing this course and whether the conducted activities improved- their knowledge and skills. Finally, the last part consists of an open-ended question to gain more in-depth responses in order to obtain qualitative data about the module.

2.4. Data collection

The Survey Field Course Questionnaire was distributed to engineering students who were taking H21V11 Engineering Survey 1 module. In this course, the students worked on field work projects in teams. The instructor gave the questionnaire to the students once before and upon finishing the field work.
Prior to administering the questionnaire, the instructor briefly read a written script about the nature of the research and the students' rights. This information was also included in the questionnaire. The instructor also informed the students that their participation is voluntary. Questionnaires were completed anonymously and no marks or other inducements were used to encourage students to fill up the questionnaires. Therefore, several students did not respond to all questions and the response rate for individual questions declined near to the end of the survey.

3. Results and discussion

3.1. Background of Survey Field Course in University of Nottingham, Malaysia (UNM)

The six-day SFC in Malaysia was conducted in campus on small scale during the month of May 2014. The event started from 9 am until 10 pm and was led by two Malaysian lecturers who have been attending the training sessions held at the UK campus. The participants consist of approximately 70% (56 students)) of local students and 30% (25 students) of international students. The students were divided into a group of five to six members. It is worth noting that English is the second language for the Malaysian students, while for the international students, English is their first language.

3.2. Demographic statistics

Participation in the survey is completely voluntary and purposeful sampling procedures were used. A total of 81 questionnaires were distributed, only 79 responses were valid for the pre-test and the post-test analysis, resulting in an overall response rate of 97.5%. A 78% of the respondents were males and the remaining 6.2 % were female students. The findings also revealed that 49.4% of the respondents have prior foundation in engineering level of education (completed in UNM), while the rest of the respondents have prior A-levels and other pre-university programme qualifications before enrolling to the Civil Engineering programme.
With regards to gender role in engineering field, these findings are corresponding to the national trends whereby male undergraduates constitute a greater percentage of enrollment into the Engineering degree programme, Most of the students chose MEng (43.2%) compared to a BEng programme due to requirements of BEM in Malaysia.

3.3. Programme outcomes attainment

In order to find out whether there was any significant difference between the attainments of five Programme Outcomes of both scenarios (pre and post test) on the survey field course, paired sample t-test was conducted.
Five out of ten statements on engineering knowledge and skills were assessed to be significantly different (p-value < 0.05), as shown in Table 2. A significant increase was noticed from the pre-test scores to the post-test scores. Hence, based on the students' perception, they were able to acquire new engineering knowledge on SFC and hence, the PO1 at module level was attained.
Table 3 reports similar findings as in Table 2. There was a significant difference between the pre-test scores and post-test scores on problem analysis (p-value < 0.05). In a way, the students felt their knowledge and skills on problem analysis were improved after the SFC. Therefore, PO2 at module level was achieved, based on the students' feedback.
In Table 4, a significant difference was also evaluated (p-value < 0.05) on items related to knowledge and skills about modern tools usage. The results showed an improvement from the pre-test scores to the post-test scores. However, no significant improvement was found when the students responded to item 13 (S13) and item 15 (S15). This may be due to the fact that the students have gained sufficient training and technical skills on operating some of the surveying instruments before they enrolled to SFC. Overall, the PO5 was attained but further improvement is needed to increase the ability to use some of the advanced features of the surveying instruments.
From the students' perception on improvements in communication skills in Table 5, it is obviously shown that PO9 was not attained. The results showed that 60% of statements, with five items on skills were assessed to be not statistically different (p-value > 0.05), knowing how to improve the communication skills and using the skills to improve communication is a different challenge. The results showed that the students were aware and equipped with knowledge on communication skills, however they were unable to acquire the techniques to improve their communication skills, both on verbal and non-verbal communication. Attention must be made to enhance students' proficiency level in communication rather than knowledge.

Table 2: PO1 Engineering Knowledge Statement Means and Statistical Significance Acquired from Paired Sample t-tests

	Statement	Pre-test Mean	Std. Dev	Post-test mean	Std. Dev	Mean Diff.	t-value	p-value
K1	I understand how the fundamental physical principles and mathematical methods apply in this SFC	2.88	0.83	3.70	0.72	0.83	-7.18	0.0000
K3	I understand the limitations of physical principles or mathematical methods learnt in this SFC.	2.70	0.88	3.76	0.77	1.06	-7.96	0.0000
K5	I know how to lay out the building plans on site.	2.35	0.93	3.70	0.81	1.34	-9.54	0.0000
K7	I understand how to identify and map the contours of the ground and existing features on the surface of the earth.	2.48	1.01	3.71	0.78	1.24	-8.02	0.0000
K9	I have a good understanding in land surveying techniques.	2.48	0.91	3.68	0.81	1.20	-8.68	0.0000
S1	I am able to calculate and identify the location of design points upon setting-out.	2.71	0.85	3.70	0.81	0.99	-7.71	0.0000
S3	I can perform the curvature and linear calculation.	2.48	0.88	3.92	0.98	1.44	-9.08	0.0000
S5	I am able to measure the peg/ground level and produce a profile diagram.	2.48	0.83	3.72	0.98	1.24	-8.80	0.0000
S7	I can perform the traversing with minimum angular and positional misclosures.	2.77	0.93	3.68	0.86	0.91	-6.41	0.0000

S9	I can integrate LSS software with AutoCAD to produce topographic map.	2.05	1.00	3.08	1.06	1.03	-6.80	0.0000

Table 3: PO2 Problem Analysis Statement Means and Statistical Significance Acquired from Paired Sample t-tests

	Statement	Pre-test Mean	Std. Dev	Post-test mean	Std. Dev	Mean Diff.	t-value	p-value
K2	I know how to apply my learnings from this SFC to related engineering problems.	2.79	0.92	3.79	0.65	1.00	-8.11	0.0000
K4	I understand how to identify potential solutions, based on what I learnt from this SFC.	2.65	0.82	3.62	1.03	0.97	-6.38	0.0000
K6	I understand how to operate and use of surveying instruments to overcome the construction related challenges.	2.79	0.82	3.90	0.89	1.11	-7.76	0.0000
K8	I understand how to effectively solve a complex engineering problem.	2.44	0.83	3.27	0.94	0.82	-5.51	0.0000
K10	I am confident in my ability to design solutions for complex and open-ended problems.	2.49	0.89	3.55	0.86	1.06	-7.63	0.0000
S2	I am able to identify potential hazardous terrain and unsecured working environment.	3.14	0.86	3.73	0.90	0.59	-3.93	0.0002
S4	I can organise and design a proper planning to execute my tasks in SFC, within the time frame.	2.62	0.76	3.66	0.90	1.04	-7.67	0.0000
S6	I am able to identify various control stations and methods for setting-out.	2.54	0.78	3.89	0.78	1.34	-10.34	0.0000
S8	I am able to perfect the accuracy of setting-out points.	2.73	0.83	3.75	0.81	1.01	-8.16	0.0000
S10	I am able to avoid obstacles during traversing and radial detailing with surveying techniques.	2.56	0.92	3.63	0.83	1.08	-7.54	0.0000

Table 4: PO5 Modern Tool Usage Statement Means and Statistical Significance Acquired from Paired Sample t-tests

	Statement	Pre-test Mean	Std. Dev	Post-test mean	Std. Dev	Mean Diff.	t-value	p-value
K11	I know how to identify various types of surveying instruments or equipments.	2.92	0.87	3.82	0.73	0.90	-7.01	0.0000
K13	I understand the function and features of the surveying instruments involved.	2.88	0.82	3.78	0.69	0.90	-8.36	0.0000
K15	I understand that accuracy of measurement is important than completing the tasks in SFC.	3.58	0.85	3.88	0.80	0.30	-2.27	0.0262
K18	I understand that total station is an advanced version of the theodolite, which can be used for both angle and elevation measurements.	3.44	1.00	4.05	0.85	0.61	-4.34	0.0000
K21	I understand that centering and levelling surveying instruments on control station are important.	3.66	0.91	4.16	0.79	0.50	-3.72	0.0004
S11	I can use levelling instrument to estimate the angle and the distance between two points.	2.97	0.91	3.63	0.90	0.65	-4.56	0.0000
S13	I am able to remove and re-setup the Total Station at the same control station, and maintain the its coordinate and elevation.	2.82	0.92	3.05	1.58	0.23	-1.11	0.2704
S15	I am able to appropriately reduce and eliminate errors in instruments and measurement.	2.95	0.80	3.19	1.45	0.25	-1.16	0.2480
S18	I can store all natural and man-made features electronically in Total Station, during radial detailing.	2.55	0.83	3.19	1.59	0.64	-3.09	0.0029
S21	I can edit and modify LSS and AutoCAD outputs on the computer in order to produce the best topographic map.	2.21	0.96	2.79	1.42	0.59	-3.12	0.0026

Table 5: PO9 Communication Statement Means and Statistical Significance Acquired from Paired Sample t-tests

	Statement	Pre-test Mean	Std. Dev	Post-test mean	Std. Dev	Mean Diff.	t-value	p-value
K16	I understand how others perceive me.	3.09	0.89	3.64	0.94	0.55	-3.90	0.0002
K19	I can identify characteristics of a good listener.	3.36	0.94	3.79	0.88	0.43	-2.82	0.0061
K20	I understand what effective communication is.	3.51	0.86	3.91	0.89	0.40	-3.23	0.0018
K22	I can identify different types of non-verbal communication.	2.95	0.91	3.80	0.82	0.85	-5.83	0.0000
K24	I understand what it means to collaborate.	3.41	0.96	3.98	0.76	0.56	-4.23	0.0001
S16	I am confident in my ability to communicate complex engineering concepts with others.	2.89	0.79	3.05	1.54	0.16	-0.81	0.4180
S19	I explain my thoughts and ideas in an organized fashion.	2.89	0.86	3.04	1.46	0.15	-0.75	0.4569
S20	I am able to collaborate with others on a given task.	3.23	0.76	3.27	1.54	0.04	-0.21	0.8380
S22	I am confident in my presentation skills.	2.93	0.93	2.97	1.49	0.04	-0.21	0.8373
S24	I am able to write and present technical reports at a level expected of the engineering profession.	2.71	0.82	2.88	1.41	0.16	-0.87	0.3851

Table 6: PO10 Individual and Team Work Statement Means and Statistical Significance Acquired from Paired Sample t-tests

	Statement	Pre-test Mean	Std. Dev	Post-test mean	Std. Dev	Mean Diff.	t-value	p-value
K12	I am aware how my personal values affect the decisions I make.	3.40	0.95	3.80	0.83	0.40	-2.96	0.0040
K14	I understand the meaning of professional ethics.	3.24	0.93	3.845	0.82	0.60	-4.52	0.0000
K17	I understand my learning style.	3.42	1.00	3.85	0.89	0.43	-2.76	0.0071
K23	I understand how I contribute to the diversity of a group/class.	3.40	0.94	3.84	0.86	0.44	-3.15	0.0023
K25	I understand how I am perceived as part of a group.	3.44	0.95	3.91	0.81	0.48	-3.39	0.0011
S12	I can effectively work with various group dynamics.	3.06	0.76	3.76	0.82	0.70	-5.741	0.0000
S14	I am comfortable leading a group discussion.	3.00	0.87	2.97	1.57	-0.03	0.13	0.8983
S17	I exhibit leadership skills in and outside of the classroom.	3.00	0.91	3.04	1.54	0.04	-0.19	0.8531

S23	I am able to see issues from other people's perspectives.	3.04	0.92	3.22	1.45	0.18	-0.92	0.3603
S25	I am able to make confident decisions when the proper amount of information is provided.	3.16	0.91	3.21	1.48	0.04	-0.20	0.8402

In Table 6, 50% of the statements about individual and team workability were assessed to be not significantly different although the results showed a slight improvement from the pre-test scores to post test scores. Based on the students' perception, they were very positive (pre-test mean > 3) about their ability to work as an individual before they took SFC. Furthermore, they also highly rated their initial strength to work as a team member. In other words, the students have maintained their initial strength to work as an individual or perform as a team member even after they completed the SFC. They probably felt satisfied with their initial skills and knowledge to work as an individual or a team member and hence their post test scores showed a minimal improvement. Hence, it is the responsibility of instructor to further increase team work spirits and individual motivation towards the objectives using proper and effective monitoring approaches. In summary PO10 was not attained due to less statistically significant evidences regardless of improvement on all score values.

4. Conclusion

In Malaysia campus, the PO9 on communication was not achieved. This is probably due to the majority of SFC participants were Malaysian students (>70%) in which English was their second language of learning. Some of them felt comfortable to speak in Malays language or local dialects (Mandarin, Cantonese, Tamil, etc) with their peers during SFC discussion. As a result, they were reluctant to speak in English with their team members. Such situation would affect their confidence level to communicate verbally in English as well as in report writing. This could be improved by properly grouping and blending local and international students. In addition, student helpers or research assistant involved in SFC as co-instructors should also be communicating with students using only English.

Another PO that was not achieved in the Malaysia campus was PO10 on Individual and Team work. Improper grouping was the main reason for this failure. Students tend to choose their friends or strong members for the group formation, and eventually there was an imbalance of group performance. One of the suggestion to improve PO10 is assigning the grouping based on certain criterias so that the students would take it as a challenge to work with others and appreciate the elements of team work.

Overall, the study was successful in regard to the POs attainment. The results indicated that there were improvements in mean value for pre- and post-tests, although some of them were not statistically significant. Some of the suggestions for future improvement were:

i) Additional pre equipment familiarization and practical session before the actual survey field course.
ii) Impose more grouping dynamics to improve the students' team building.
iii) Introduce team building activity for students to improve their interpersonal skills.
iv) Introduce problem analysis activity for students before the actual survey field course.
v) Conduct the survey field course off campus so that students can learn how to work, live and study together.

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