From Outcome-Based Education (OBE) to Continual Quality Improvement (CQI): A Case Study of Teaching Mechanical Engineering at University of Newcastle, Singapore

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Abstract

The Outcome-Based Education (OBE), which is an education philosophy that focuses on the graduate attributes or outcomes upon the completion of an engineering programme, is an important component in the conduct of Engineering Programme in Malaysia and Singapore. For the case in the University of Newcastle, Australia (Singapore Campus), The Programme Outcomes (PO) of the engineering programme is first determined in the curriculum, for which the Learning Outcomes (LO) of the courses in the programmes are designed based on the PO stated. In addition, the students' achievements of such outcomes are measured upon completion of courses and programmes. As part of Continual Quality Improvement (CQI), these measurements are analysed and steps for improvements are taken. This paper presents a case study conducted for teaching of the course of Transport Phenomena in the University of Newcastle, Singapore, where the LO measurement is used as an input for CQI process, in particular, the incorporation of teaching and learning feedback practices "start-stop-continue" into the OBE measurement and CQI, and how action are taken for improvements.

Keywords

Outcome-Based Education (OBE), Continual Quality Improvement (CQI), start-stop-continue, Engineering Education, Learning Outcomes (LO)

Introduction

The Outcome-Based Education (OBE) is an educational philosophy that focuses on the attainment of outcomes upon completion of the programme. The implementation of OBE has become a norm in engineering education, particularly for the accreditation of engineering programme under the signatory countries of Washington Accord (Memon, Esra Demirdogen, & Chowdhry, 2009), such as Malaysia and Singapore. Inevitably, OBE leads to the specification of Learning Outcome (LO) to be explicitly spelt out and put emphasis on assessment of the associated LO attainment (Andrich, 2002). However, over emphasizing on the assessment of LO attainment can lead to too much time spending on administering assessment, leaving minimal time for lecture preparation (Todd & Mason, 2005). Eventually, students do not benefitted from the implementation of OBE even though their learning achievement can be clearly identified based on the assessment of LO attainment.

On the other hand, another emphasis is on gathering student feedback on courses and programmes. Of student feedback systems, the model of 'Start-Stop-Continue' has been demonstrated to be used constructively on many disciplines (Hoon, Oliver, Szpakowska, & Newton, 2014). Nevertheless, the student feedback often biases towards the adaptation that academic staff can make in enhancing

teaching approach without self-reflection on individual learning achievement (Bovill, 2011). Consequently, the student feedback is not sufficient to be used as the inputs to propose effective action plan for Continual Quality Improvement (CQI).

In short, the implementation of OBE and evaluation of student feedback cannot be separated. Therefore, the aim of this paper is to demonstrate the implementation of OBE incorporate with the evaluation of student feedback of "start-stop-continue" through the case study of teaching the course of Transport Phenomena in the University of Newcastle, Singapore (UONS). In this sense, the students learning achievement and their personal feedbacks can be correlated and used as an input to propose an action plan for CQI in an unbiased manner.

The course is a level three core course for students in the programme Bachelor of Engineering in Mechanical Engineering. In this case study, a total of 37 students enrolled and completed the course for Trimester 2, 2014, which was conducted from May to August 2014.

In general, the course covers two areas of study in the Mechanical Engineering, namely Fluid Mechanics and Heat Transfer. Students who enrolled this course must have completed courses on Basic Fluid Mechanics and Thermodynamics. The LO of the course is briefly described as follow:

On successful completion of this course, students will be able to:

1. *explain the principles of transport of mass, momentum, and heat.*
2. *describe transport processes and apply the transport equations.*
3. *solve problems relating to transport phenomena using appropriate methods.*
4. *assess the plausibility of her/his solution*

The LO of the course is designed based on the Graduate Profile Statements, where the course builds students' capacity with reference to the Engineers Australia Stage 1 Competency Standards for Professional Engineers (Graduate Attributes). At such, each outcome is mapped to the assessment, and also Graduate Profiles Statements.

The assessments of this course are divided into three components: quizzes, written assignments, and group/tutorial participation and contribution. Quizzes, contributes to 60% of the total course marks. Three quizzes of 20% each are conducted every four weeks of during the trimester. Each quiz consists of four structured-type questions, where students are required to answer all four questions in the 2-hour duration. Students are given two written assignments, where the first assignment is the essay-type assignment on the area of fluid mechanics and the second assignment is the structured-type questions in the area of heat transfer. The group/tutorial participation and contribution component contribute 20% of the total course marks. This part of the assessment is achieved in two: submission of selected tutorial questions and laboratory report.

The remaining of the paper is organised as follow. The paper starts with the details the mechanism of the implementation of OBE and discuss the associated LO attainment. This is then followed by the description of student feedback models in term of "start-stop-continue". Then, the adoption of student feedbacks will be discussed. Action plan for CQI based on LO attainment and student feedbacks will be proposed. The paper concludes with the summary of overall research achievement and highlights the key findings.

Implementation of Outcome-Based Education (OBE)

In a nutshell, the implementation of OBE for Transport Phenomena course is concentrated on the extent to which the students have achieved the stipulated LOs (Md Zain, et al., (2012), Osman, et al., (2012)) as mentioned in previous section. The aim of this section is to present a method of assessing the attainment of LOs. The key step is to map the coursework assessment components with the corresponding LOs as shown in Table 1. For simplicity, all mapped LO carry the same weightage.

Table 1: Mapping of LOs and Assessment Components

	Quiz 1 (20 marks)	Quiz 2 (20 marks)	Quiz 3 (20 marks)	Assignment 1 (10 marks)	Assignment 2 (10 marks)	Laboratory (20 marks)
LO1	✓	✓	✓	✓	✓	✓
LO2	✓	✓	✓			
LO3	✓	✓	✓		✓	
LO4				✓		✓

For each student, a particular LO is said to be achieved if his/her LO mark is equal to or greater than the target set as 50%. As an example, when computing LO2 attainment for Student *X*, the LO2 is mapped with Quiz 1 – 20 marks, Quiz 2 – 20 marks, Quiz 3 – 20 marks as shown in Table 1. Suppose the Student *X* obtains 12 marks in Quiz 1, 8 marks in Quiz 2 and 13 marks in Quiz 3, the procedures to calculate the LO2 attainment for Student X are as follows:

$LO2\ Marks = 12 + 8 + 13 = 33\ marks$

$Maximum\ Possible\ LO2\ Marks = 20 + 20 + 20 = 60\ marks$

$$LO2\ Attainment = \frac{(LO2\ Mark)}{(Maximum\ Possible\ LO2\ Mark)} \times 100\% = \frac{33}{60} \times 100\% = 55\%$$

Therefore, the LO2 of Student *X* is considered achieve, as it has exceed the target set as 50%.

The computation for all the LO attainments of all the 37 students are similar. In this case study, the Key Performance Index (KPI) of LO attainments is set as 75%. The KPI is measured in such a way that the percentage of student number meeting the target of 50%. For instance, suppose there are 9 out of 37 students obtain at least 50% of LO2 attainment, which indicates that only 9/37 = 24.32% of students achieve LO2. In this case, the KPI of 75% has not been met. It is noted that measurement of LO attainments are merely based on the student academic achievement without consideration of student learning experience. In the next section, the feedback mechanism will be described, which allows student learning experience to be captured.

The Feedback Mechanism – Start-Stop-Continue

The Start-Stop-Continue (SSC) feedback mechanism has been implemented by the author since 2008 (Koh, 2013) to improve the teaching practices as well as to improve the learning experiences among engineering students.

At the end of semester/trimester, the feedbacks from students are collected as reference for improvement for the coming semester/trimester. In the SSC strategy, instead of using questions based on Likert's scale answer, students are required to fill in the SSC form, as shown in Figure 1.

START	STOP	CONTINUE	COMMENTS / ACTION PLANS

Figure 1: The example of an SSC form

The form is divided into four columns, namely "Start", "Stop", "Continue" and "Comments/Action Plans", which are explained as follow (Koh, 2013):

"Start" **–** This column is provided to students to inform the lecturer on what the lecturer should **START** doing to improve the students' learning.

"Stop" **–** This column is provided to students to inform the lecturer on what the lecturer should **STOP** doing to improve the students' learning.

"Continue" **–** The column is provided to students to comment on anything that the lecturer has been doing in the class, and they feel that the lecturer should **CONTINUE** doing this to enhance their learning experience of the subject.

"Comments/Action Plans" **–** This is an extra column that is created to provide lecturer with some information on students' action plan so that he can make necessary adjustments in his teaching to help them in making learning possible.

Results discussion for LO attainments

This section presents the results of LO attainment as shown in Figure 2, where the attainment of LO1 is 78.38%, LO2 is 24.32%, LO3 is 32.43% and LO4 is 100%. Clearly, there are only LO1 and LO4 meet the KPI of 75%, whereas LO2 and LO3 are far below the KPI.

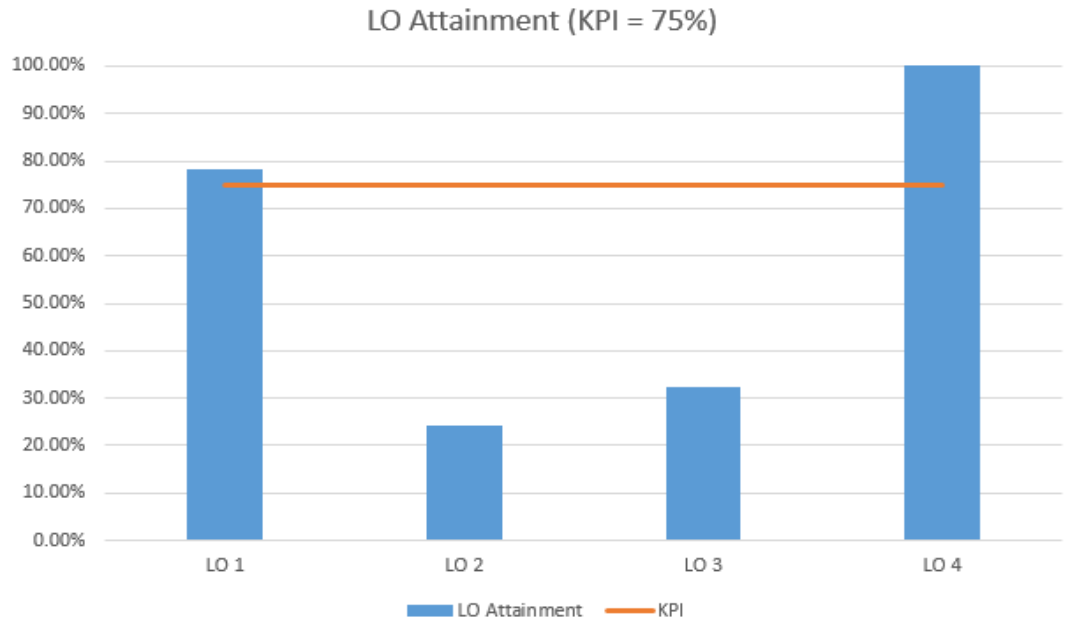

Figure 2: LO Attainments Result of Transport Phenomena Students

The results reflect that this cohort of students faced difficulties when come to the assessments that require them to complete a task in the given time frame and less preparation time. This observation is reflected on the low achievement on LO2 and LO3, which is well below the KPI. Mentioned previously, quizzes are conducted every four weeks of the 12-teaching-week trimester. This means that students will not be having the luxury of study vacation to prepare the assessments. In such condition, only those who are putting continuous effort survive in the assessments. In addition, LO2 is also measured through Assignment 2, which is an in-class Assignment. In this case, although students are allowed to discuss on the strategy of solution, however, the condition is similar to the quizzes, where the success of the attempt is based only on the continuous effort in the course.

On the contrary, LO1 and LO4 have relatively high achievements on the LO attainment, and both LO1 and LO4 met the KPI. Looking back to the mapping shown in Table 1, LO1 and LO4 are mainly measured through written research assignment and laboratory report. In this case, students have more time to prepare themselves to explain the concept well, leading to the better understanding and hence better performance.

The attainments of all the LOs have been measured. However, it could be biased to student assessment if the action plan for CQI is proposed merely based on LO attainments. In order to propose action plans for CQI in an unbiased manner, the student feedback on learning experience will be considered in the next section.

Improvements from Students' Feedback

Summarising the feedbacks on START and STOP, the following items are obtained:

- Start go through laboratory manuals for better understanding
- Start to have more explanation on tutorial questions
- Start making lecture slides available online
- Stop giving difficult examination questions
- Stop giving simple example questions / start giving harder tutorial questions
- Stop teaching too fast
- Stop research assignments

Summarising the feedbacks on CONTINUE and COMMENTS, the following items are obtained:

- Continue giving examples in the class
- Continue teaching style / teaching with integrity
- Continue being awesome
- Teaching is easy to understand and to relate
- Keep up the good work
- Nothing bad actually, just something needed to help me absorb better

The feedbacks shown above are those of high frequency of appearance, which focus ought to be paid for improvements or continuation. From the feedbacks, the following improvements are planned for the next round of teaching:

- Lecture notes, lecture slides with examples, tutorials are uploaded on the BlackBoard (learning management system in UONS) before the start of the trimester. In particular, the number of examples on how transport equations can be applied in solving complex engineering problem need to be increased, which helps to address the low attainment of LO2.

- Instead of having one research assignment and too taxing on laboratory report, the introduction and literature review is made as part of other assignments to distribute the load and stress of working on the report. Students are strong in achieving LO4, and this part should be maintained by helping them to cope with the maintenance of the attainment of LO.
- Further explanations are provided during the tutorial classes, and then only focus on individual progress.
- For each example in the class, the focus on solution technique / understand of skills are explained, so that students will not be seeing the examples are simple and straight forward. Together with the previous point, improvements on the score in LO2 and LO3 can be targeted, where students are provided with the necessary information to apply the right concept when come to the solution of the questions.
- The level of difficulty and quality of quizzes will not be compromised and remains the same, as the questions are up to the standard of level three students.
- Continue to be awesome!

Conclusion

In the case study, the effectiveness of the OBE implementation incorporated with the feedback mechanism – Start-Stop-Continue has been demonstrated. It has been measured that only LO1 and LO4 have met the KPI of 75%, where LO2 and LO3 are far below the KPI. The LO attainments are found to be highly dependent on the nature of assessments, where the assessments are either coursework based or exam based. However, with the support of student feedback – Start-Stop-Continue, the LO attainments somewhat gives an input to effectively propose the action plans in an unbiased manner for CQI purpose. Therefore, the proposed action plans are reasonably profound, since both of the student performance and learning experience have been taken into consideration. In conclusion, the process from OBE to CQI in this case study is reasonably effective.

In future research, the LO statements could be refined in more detail manners so that LO attainment can be more specifically reflect the student performance. Subsequently, the resulting LO attainments from refined LO statements enable more specific action plan to be proposed for CQI purpose.

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