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Outcomes-Based Assessment and Learning: Trialling Change in a Postgraduate Civil Engineering Course

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Abstract

This paper aims to demonstrate how assessment tasks can function within an outcomes-based learning framework to evaluate student attainment of learning outcomes. An outcomes-based learning framework designed to integrate teaching, learning, and assessment activities was developed and implemented in a civil engineering master-level course. The assessment instruments for this course were designed together to form a deliberate, balanced, and practical approach to evaluating student attainment of learning outcomes within the outcomes-based learning initiative. Direct evidence of student learning was derived through analysis of student results in assessment tasks constructively aligned with intended outcomes of learning. Student feedback provided indirect evidence of student attainment of learning outcomes and confirmed the effectiveness of the learning approach implemented in the course under investigation. Results of the direct assessment instruments were, generally, consistent with the student self-perception confirming achievement of learning outcomes. Students tended, however, to overestimate the level of attainment of learning outcomes. Results of the present study are anticipated to assist educators and researchers to efficiently and effectively implement and evaluate outcomes-based learning in higher education thus improving educational quality and student learning

Keywords

outcomes-based, learning, assessment, student feedback, perception

Cover Page Footnote

The authors gratefully acknowledge the generosity of students for their volunteer participation in the surveys. This initiative was conducted in compliance with existing institutional ethical guidelines.

Introduction

Enhancing educational practice and student learning is an area of importance in higher education worldwide, as shown by widespread emphasis on systems of standards and evaluation. The Bologna Declaration advocates adoption of meaningful criteria and methodologies for quality assurance in European higher education (Bologna Declaration 1999). The Western Association of Schools and Colleges (WASC) accreditation agency requires all educational programs seeking accreditation at the undergraduate and graduate levels to establish student learning outcomes, develop plans for assessments and use the results to enhance student learning (Lindholm 2009; WASC 2013). Similarly, the United Arab Emirates (UAE) has a national Qualifications Framework (QF*Emirates* 2012) established by National Qualifications Authority (NQA). The QF*Emirates* provides a frame of reference for the quality of learning qualifications that places student outcomes as a core focus.

The first author's institution (UAE University) is going through quality-assurance (QA) and quality-enhancement (QE) processes that reflect local and global priorities. The institution's approach has required changes not only in the execution of curricula, but also in the underlying structure and approaches to student engagement, especially in the area of assessment. Achieving deep change in higher-education curricula is, however, notoriously difficult, particularly in the area of assessment (Deneen & Boud 2014; Trowler et al. 2003). Thus, analysing and reporting has become an essential part of the QA and QE processes.

The outcome-based learning (OBL) approach has been adopted in the first author's institution. OBL is a student-centred approach that focuses on academic outputs rather than educational inputs (Barkley & Major 2016; Biggs & Tang 2007; Carless 2015). It is a well-recognised approach to reconstructing curricula to better align learning and assessment with the intended outcomes of learning (Arshada et al. 2012; Biggs & Tang 2007; Cox 2009; Hendry 2014; Hughes 2013; Lixun 2011; Osman et al. 2012; Wahab et al. 2011). Implementing OBL in higher education is a challenging task; several interrelated activities pertaining to teaching, learning and assessment must be conducted concurrently. Proper constructive alignment between teaching, learning, assessment activities and learning outcomes is crucial for successful implementation of the OBL approach (Barkley & Major 2016; Biggs & Tang 2007).

OBL is not without controversy. Critics say it can be perceived and resisted as an external imposition that ignores context or stifles innovation, especially in assessment (Deneen & Boud 2014). Similarly, the adoption of an OBL approach must avoid the significant challenges of "conceptual reification and rigidity in implementation" (Ewell 2005, p. 27). The adoption of an OBL approach to enhancing and assuring quality must be accompanied by a careful examination of the legitimacy of the process, the perceptions of stakeholders, the outcomes and the relationship of assessment to the enterprise.

The aim of this paper is to report findings from a research study on the perceptions and associated learning outcomes of students in an OBL trial. An OBL framework designed to integrate teaching, learning and assessment activities was developed and implemented in a civil engineering master's level course offered at the first author's institution in the second semester of the 2014-2015 academic year. The assessments for this course were designed together to form a deliberate, balanced and practical approach to evaluating students' attainment of learning outcomes within an outcomes-based learning framework. The objectives of this study were to determine 1) how the assessments function in relationship to an OBL framework and to student achievement, 2) the

perceptions of students in the trialled approach and their achievement and 3) whether the approach appears to meet desired benchmarks of innovation.

This paper presents a context for the trial by reviewing salient areas of the literature. The institutional context and trial are then presented, along with the means by which data was collected and analysed. Results are then presented and their significance is discussed. The results are intended to inform higher education educators and researchers seeking to use OBL effectively, especially in terms of achieving constructive alignment, fostering positive student response and affecting educational quality and assessment practices.

Literature review

Enhancing higher education

QA and QE in higher education are concerns worldwide. QA may be understood as processes of reporting and accountability that construct an evidence-based case of an institution meeting credible internal and external aims and objectives (Nicolson 2011; US Department of Education 2006). QE then is the formative means by which these processes and their accompanying responses are developed (Nicolson 2011). QE may include a host of activities; one activity deemed essential is trialling techniques that improve student learning and better align assessment with curricula in terms of supporting and accounting for achievement (Deneen & Boud 2014). This study may be seen as fitting within this framework of the relationship of QA and QE(henceforth referred to as QA/QE).

Higher-education institutions and accrediting bodies see outcomes as central to QA/QE processes. Learning outcomes provide key benchmarks for maintaining standards, judging educational quality and enhancing teaching and learning (Biggs & Tang 2007; Carless 2015; Hughes 2013). In the Bologna Process, learning outcomes play a critical role in enhancing and developing equivalence in the standards and quality of European qualifications (Bologna Declaration 1999). All undergraduate programs seeking accreditation from the Engineering Accreditation Committee of ABET (Accreditation Board for Engineering and Technology) must demonstrate that they accomplish learning outcomes that prepare graduates to attain their program objectives (ABET 2014). ABET learning outcomes describe what students are expected to know and be able to do by the time of their graduation (ABET 2014). The WASC accreditation process requires both undergraduate and graduate programs to document evidence of students' achievement of intended learning outcomes (WASC 2013).

Such approaches place students' outcome achievement at the centre of QA/QE. Changing educational practice to reflect an enhanced student focus represents a challenge to many institutions of higher education. Such changes require thoughtful actions that develop and connect learning, teaching, assessment and curriculum (Trowler et al. 2003). Assessment is a critical aspect of this, as it provides evidence of student achievement and may be used as part of an outcome-oriented QA/QE process (Carless 2015; Ewell 2005). As quality and accreditation processes centre more on outcome achievement, assessment must change to meet these demands. Achieving change in assessment practices in higher education, however, is challenging, complex and difficult to manage, and often meets with resistance (Deneen & Boud 2014). There are many reasons for this. Assessment change is difficult to model or sustain past the trial phase of an initiative (Trowler et al. 2003). Actual outcomes of such initiatives are often quite different to the intended outcomes (MacDonald & Joughin 2009). Staff and students who do not perceive the change as an authentic opportunity for enhancement may resist or even subvert the initiative

(Bromage 2006; Deneen & Boud 2014; McInnis 2006; Trowler & Bamber 2005). This may account for a paradox in higher education: while assessment may seem the best area to focus on for productive change, it is often the least successful (McInnis 2006).

Trial and study of such changes are therefore warranted. Specifically, these challenges call for a trial that focuses on assessment, provides a model or framework for aligning assessment with outcomes and learning and takes into account the perspectives of stakeholders involved in the trial. The trial reported in this study was developed in response to these imperatives and challenges.

Outcomes-based approaches to changing curricula

Barkley and Major (2016) identified three interrelated components for effective pedagogy: (1) identifying and communicating clear learning goals and outcomes, (2) helping students achieve these outcomes through active/engaged learning and (3) analysing, reporting and reflecting on results to improve learning. Implementing these interconnected components in higher education necessitates a change in educational practices to focus on what students have to learn rather than what educators have to teach. Implementation of OBL requires a shift from educational inputs to outputs in the form of direct and/or indirect evidence of student achievement to judge educational quality. For the purposes of this study, direct evidence consists of data that directly indicates student achievement. Indirect evidence consists of data on students' perception of achievement. Figure 1 summarises an outcomes-based learning framework. Assessment of student learning is central in this process because student performance in assessment tasks, constructively aligned with intended learning outcomes, can be used to identify what students have learnt and achieved.

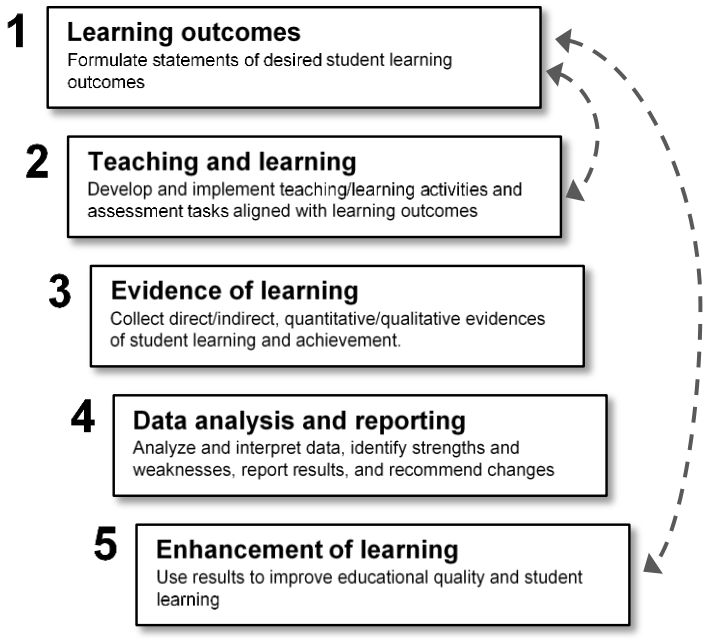


Figure 1. Outcomes-based learning framework

An outcomes-based learning approach aligns well with the QF*E*mirates and with the three components of the effective pedagogy identified by Barkley and Major (2016). OBL approaches at institutional, program and course levels often have different, albeit interconnected, goals. For the

purposes of this paper, "institution" refers to the whole university; "program" refers to a sequence of study ending in a degree (in this case, a master of science in civil engineering); "courses" are the specific units of study, consisting of different topics and taught over the period of a semester, as part of a program; and "modules" are topic-based learning engagements that the student experiences as part of a course.

An OBL approach at the institutional level is typically used for large-scale evaluation and accountability; hence, it often focuses on generic graduate attributes (Biggs & Tang 2007; Carless 2015). An OBL approach at the program level is established in a way that students can achieve specific discipline-oriented program goals. This cascades into learning outcomes at the course level. Governments and international and national accreditation agencies require evidence of student achievement and learning at the course, program and institutional levels to judge the quality of education.

Successful enactment of OBL in higher education requires constructive alignment between teaching, learning activities, assessment tasks and learning outcomes at the course level, proper mapping of course learning outcomes to program learning outcomes and reconciliation of program-specific learning outcomes with the desired generic graduate attributes at the institutional level. There is a risk, though, that this interconnectivity may mutate the function of OBL to be a bureaucratic burden rather than a useful tool to promote and improve student learning (Carless 2015; Carless & Zhou 2016; Deneen & Boud 2014; Hussey & Smith 2008). Similarly, different stakeholders may have different perceptions of an OBL initiative, which may affect the experience and "buy-in" to the initiative (Deneen et al. 2013). Research is therefore needed to examine impact and stakeholder perceptions of a particular OBL approach adopted by an institution.

Innovative assessment

Assessment is required in education to demonstrate students' learning, judge their performance, satisfy demands for accountability and, more importantly, support and advance student learning (Carless 2015). It should serve formative and summative purposes. Innovative assessments focus on the immediate assessment task, but also prepare students for lifelong learning (Boud & Falchikov 2006; Boud & Soler 2016; Nguyen & Walke 2016). Innovative assessments may often perform double duty: a single task should allow for both formative and summative purposes to be fulfilled (Boud & Soler 2016). Such tasks often harness student engagement in the educational process, enhance their experience and reflect on their learning (Carless & Zhou 2016; Fisher et al. 2005; Johnston et al. 2011; Killen 2000; Mitchell & Delaney 2004, Zhou & Deneen 2016). Planning for innovative assessment is therefore necessary as part of an OBL approach. Given the twin challenges of OBL and assessment change in higher education, it is all the more important to build research and analysis into the change initiative, in terms of both objective enhancement of the curriculum and relevant stakeholders' perceptions of the changes.

Assessment of learning outcomes at the program level should map onto a similar course-level process. Instructors typically devote considerable time and effort to delivering course content, scoring and analysing student work and determining student grades. Barkley and Major (2016) highlighted the main distinction between grades and assessment.

> Grades are given to individual students and are internal to specific class section, while assessment is focused on evaluating the achievement of all students enrolled in the course (and sometimes all sections of a course) and the data is intended to be shared primarily with external stakeholders (Barkley & Major 2016, p. 53).

The lack of alignment between teaching, learning activities, assessment tasks and intended learning outcomes is a major obstacle that hinders the use of student grades in assessing student achievement of learning outcomes (Rogers 2003; Shanableh 2014). The use of student grades to judge student attainment of learning outcomes without paying attention to whether the delivered contents and assessment policy are in alignment with intended learning outcomes may produce misleading results (Rogers 2003; Shanableh 2014). By contrast, proper implementation of OBL and constructive alignment of innovative assessment tasks with learning outcomes may allow student grades to serve as defensible evidence of student learning.

This paper reports findings from a study of an assessment innovation initiated as part of a larger OBL-oriented change. An OBL framework designed to integrate teaching, learning and assessment activities was developed and implemented at the first author's institution. New assessment tasks were developed and implemented to engage students in innovative practices in alignment with outcomes-based learning changes, and to represent what students would produce as an outcome of their study. Students were engaged in project-based assessment tasks designed not only to evaluate and demonstrate their learning but also to prepare them for what they might encounter in future settings. The assessment innovation reflected identified characteristics of successful assessment change.

Context of the study

In 2010, within the UAE, Federal Decree No. 1 "Establish and maintain the National Qualifications Authority" (NQA) was issued. The NQA approved the qualification framework for the UAE, known as the QF*Emirates* in 2012. All institutions providing higher education in the UAE are expected to align their credentials (certificates, diplomas and degrees) with the QF*Emirates*. The Commission for Academic Accreditation (CAA) is charged with monitoring compliance with the provisions of QF*Emirates* and international standards. This is accomplished through licensure of higher-education institutions and accreditation of individual programs.

National qualifications authority/qualification framework of the Emirates

The QF*Emirates* defines qualifications based on learning outcomes rather than content or time spent on a program (QF*Emirates* 2012). The focus is on description and achievement of outcomes that reflect level-specific qualifications, from the most simple to the most advanced levels of learning. The QF*Emirates* describes the learning outcomes in terms of knowledge, skills, and aspects of competence. Aspects of competence are expressed in terms of autonomy and responsibility, role in context and self-development. Thus, the QF*Emirates* framework encourages an OBL approach that operates at institution, program and course levels.

The master of science program in civil engineering

Civil engineering is designated a priority educational area in the UAE. Rapid development of the UAE has placed increasing demands for development of infrastructure, transportation networks and both residential and industrial complexes. In response, the department of Civil and Environmental Engineering (CEE) at the first author's institution (UAE University) established a master of science (M.Sc.) graduate program in civil engineering in 2007. The first author was the director/coordinator of the program and the chair of the graduate studies committee of the CEE department from 2011 to 2015.

As a response to QF*Emirates*, UAE University began trialing an OBL approach in postgraduate education. The M.Sc. graduate program began shifting its focus to student achievement outcomes.

Initially, a set of program learning outcomes (PLOs) were developed in alignment with QF*Emirates* Handbook (Table 1). The PLOs are broad in scope, as they specify knowledge, skills and competencies that students are expected to achieve by successful completion of the program.

Table 1. Learning outcomes of the M.Sc. program in civil engineering at UAE University

Outcome	Description
PLO1	Describe highly specialised civil-engineering principles, concepts and methodologies.
PLO2	Evaluate the performance of advanced civil-engineering systems and components through the use of applicable research principles, analytical methods and modelling techniques.
POL3	Conduct advanced applied research to develop innovative solutions for highly complex civil-engineering problems through the use of appropriately selected research methodologies and modern engineering tools.
PLO4	Apply advanced multidisciplinary problem-solving approaches to critically analyse contemporary, sophisticated and highly complex civil engineering problems.
PLO5	Present and critique highly complex civil-engineering issues and communicate effectively at a high level of proficiency.
PLO6	Lead professional activities and manage ethical issues in highly complex civil-engineering projects.
PLO7	Implement the social, environmental, ethical, economic and commercial aspects to develop valid decisions affecting highly complex civil-engineering projects.

OBL intervention in the postgraduate course CIVL 616

The course Rehabilitation of Structures – CIVL 616 is a master's level, three-credit-hour elective graduate-level course offered by the CEE Department at UAE University. In previous years, a traditional input-oriented model focusing on content coverage had been adopted in the course. Using the new PLOs, the course was redesigned to focus on outcomes rather than inputs. Development of course learning outcomes (CLOs) served as a starting point to shift the understanding of quality towards student achievement rather than the instructor's content coverage (Table 2). The CLOs align with the PLOs but are narrower in scope. Each outcome is observable, measurable and capable of being understood by students, faculty, external agencies and stakeholders. Since CIVL 616 is an advanced course offered to graduate students, there is an increased emphasis on application of knowledge and advanced development of skills and competencies.

The shift to an OBL approach necessitates a significant change in assessment (Table 3). Assessment tasks have been diversified to emphasise student engagement in the learning process and provide increased opportunities for demonstrating attainment of course learning outcomes. The new assessment tasks include laboratory projects and research papers; these are designed to support and determine within-course achievement as well as to support students' attainment of skills that might be required of a civil engineer beyond the course, in keeping with principles of sustainable assessment (Boud & Soler 2016; Boud & Falchikov 2006; Nguyen & Walke 2016).

Table 2. Comparing traditional course objectives with the new course learning outcomes

Traditional course outline	OBL course outline
Course objectives:	*Course learning outcomes:*

1. Introduce students to causes of concrete deterioration and damage mechanisms. 2. Familiarise students with evaluation techniques for structural condition assessment. 3. Introduce students to methods of repair and rehabilitation of existing structures. 4. Introduce students to principles of structural strengthening using advanced composites.	Upon completion of the course, students should be able to: CLO1. Describe damage mechanisms and principles of structural strengthening. CLO2. Identify causes of defects, cracks, damage and deterioration of concrete structures. CLO3. Develop an appropriate repair strategy for a deficient structure, taking into consideration the social, economic and commercial aspects. CLO4. Perform analysis and design of reinforced concrete elements strengthened with advanced composites, using appropriate problem-solving approaches and international code provisions. CLO 5. Conduct experiments for condition assessment, corrosion monitoring and strengthening of columns using advanced techniques. CLO6. Report findings and critique recent research on assessment and rehabilitation of structures. CLO 7. Communicate effectively with peers and clients at a high level of proficiency.

Table 3. Comparison of assessment tasks in the old course outline and new OBL course outline

Assessment tasks in the old course outline	Assessment tasks in the new OBL course outline
1. Mid-term exam (30%)[a] 2. Final exam (30%)[a] 3. Three assignments (40%)[a]	1. Exam 1 (25%)[a] 2. Exam 2 (25%)[a] 3. Assignment 1 (10%)[b] 4. Assignment 2 (10%)[b] 5. Laboratory project written report and presentation (15%)[c] 6. Research paper and presentation (15%)[c]

[a] Individual assessment.
[b] Group assessment.
[c] Group assessment for the written document and individual assessment for the presentations.

The laboratory project aimed to provide students with hands-on training and to serve as a learning activity. Students were required to conduct testing, use analytical approaches for performance evaluation, make comparisons with predictions of international guidelines and standards, analyse data and report results. For the research paper, students reviewed and discussed original and recent journal articles, describing a major scientific advancement in a research area related to course topics. Students made presentations, submitted reports and participated in discussions. The laboratory project and research paper were used as learning activities and assessment tasks, since they required the development of new knowledge, skills and dispositions or extension of those introduced in the undergraduate studies. Sample hands-on learning activities conducted during the laboratory project are shown in Figure 2.


Corrosion monitoring test


Bulk resistivity test


Ultrasonic pulse velocity test

Figure 2. Sample hands-on learning activities conducted during the laboratory project

Students worked in groups in the homework assignments, laboratory project and research paper to foster collaborative investigation. For the laboratory project and research paper, each group submitted a written document and delivered an oral presentation; this was to enhance students' technical writing and communication skills. Two exams were included in the assessment plan to give students the opportunity to demonstrate individual achievement (Killen 2000).

Successful implementation of OBL requires proper mapping between CLOs and PLOs and "constructive alignment" between teaching, learning activities, assessment tasks and intended learning outcomes (Biggs & Tang 2007). The assessment tasks adopted in this course were "constructively aligned" with intended CLOs that were mapped to specific PLOs (Table 4). This indicates that the course of the current study has been developed as a legitimate OBL approach.

Table 4. Alignment between CLOs, PLOs and assessment tasks

CLOs	Program learning outcomes (PLOs)							Assessment task[a]
	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	
CLO1	x							HW1, HW2, EM1, EM2
CLO2	x							HW1, EM1
CLO3	x	x		x			x	HW1, EM1
CLO4	x	x		x				HW2, EM2, LR
CLO5		x	x					LR, LP
CLO6			x		x	x		LR, LP, RR, RP
CLO7					x	x		LP, RP

[a] HW = homework, EM = Exam, LR = Lab report, LP = Lab presentation, RR = Research paper report, RP = Research paper presentation.

Methodology

The research addresses the questions: (1) How can assessment tasks function within an OBL framework to evaluate student attainment of learning outcomes? and (2) What does direct and indirect evidence indicate regarding the effectiveness of an OBL approach that uses innovative assessment?

Participants

The CIVL 616 course under investigation included 12 master's students. The course was delivered by the first author. Evidence of student achievement of course learning outcomes was collected through three types of data: one direct and two indirect (Table 5). Student participation in the surveys was voluntary. Surveys were distributed at the end of the course. Appropriate protocols for maintaining anonymity were observed. The student self-assessment survey of course outcomes was distributed and collected by the first author. It did not include any questions related to student identity (such as student's name or ID number). The online student course evaluation survey was administered by the Planning, Academic and Institutional Development Department (PAIDD) at UAE University. PAIDD maintained confidentiality of student identity. Since the surveys employed in the current study were anonymous to the authors, there was no risk of coercion. Results of the current study are reported only as aggregate data to maintain participants' anonymity and confidentiality.

Table 5. Direct and indirect evidence of student learning

Assessment task	Direct/indirect	Focus
Two exams Two homework assignments Laboratory project Research paper	Direct	Actual student achievement of course learning outcomes
Student self-assessment survey of course outcomes	Indirect	Student self-perception of achievement of course learning outcomes
Online student course evaluation survey	Indirect	Effectiveness of the learning approach Alignment between the teaching, learning activities, assessment tasks and intended learning outcomes Value of the course from student perspective

Data collection

Students' work in the direct-assessment tasks was evaluated by the first author using criterion-referenced assessment. Direct evidence was derived through analysis of student results in the exams, laboratory project, research paper and homework assignments. The homework assignments, exams and laboratory project were carefully designed to directly measure student attainment of CLO1 to CLO4 (Table 4). The laboratory project was also used along with the research paper in assessing student attainment of CLO5 to CLO7 (Table 4).

The indirect measures included a student self-assessment survey of course outcomes and a standard online student course evaluation survey (Table 5). Students completed the surveys by the end of the semester before the final assessment task was handed back; hence, their opinion was based on an incomplete picture of the grade they would get. In the student self-assessment survey

of course outcomes, a customised questionnaire was used to obtain students' perceptions of course learning outcome achievement. Students were asked to rate their level of achievement of each course learning outcome from *very low* to *very high* on a five-point Likert-type scale.

Although the standard online student course evaluation survey is general in approach, it includes key items that can be used to assess the effectiveness of an OBL learning approach and the alignment between the learning activities, assessment tasks and intended learning outcomes. For the purposes of this paper, the word "objectives" included in some of the survey items was replaced by the word "outcomes". The key survey items were used to explore students' perceptions of the value of the OBL aspects of the course. Students were asked to indicate the degree of their agreement with each statement using a five-point Likert-type scale. Six survey items were relevant to the current study:

1. The course [outcomes] were clearly explained.
2. There was close agreement between the stated course [outcomes] and what was actually covered.
3. Evaluation methods were clearly explained.
4. The assignments in the course were clearly related to the course [outcomes].
5. The general climate in this course was good for learning.
6. The course added to my knowledge in my major.

It is possible in the future to break item 4 of the online student course evaluation survey into multiple items corresponding to specific assessment tasks. The decision not to do so in this iteration of the research reflects the balance researchers must always strike between increasing how fine-grained an instrument is and engendering "survey fatigue" among users. A "per-task" evaluation could be undertaken in future studies, which may yield a finer-grained picture of course assessment.

Approach to analysis

Actual student performance: Student performance, indicated by their average earned grades in the direct-assessment tasks linked to each CLO, was used as a direct evidence of student learning. Accordingly, student attainment of a specific course learning outcome was calculated by averaging student scores in all assessment tasks linked to the CLO in question (Eq. 1). The attainment level of each course learning outcome expressed as a percentage, AL_i, can be represented on a five-point scale using Eq. 2 to obtain the attainment-level weight value in the range of 1 to 5; this allows results of actual student performance to be compared to students' perception of outcome achievement. A course learning outcome *i* was considered achieved when the corresponding student attainment level based on actual student performance, AL_i, was in the range of 70% to 80% (i.e. $3.5 \leq ALW_i \leq 4$). For student attainment level of $AL_i > 80\%$ (i.e. $ALW_i > 4$), the CLO was considered adequately achieved.

$$AL_i = \frac{1}{n}\sum_{j=1}^{n} SR_j \qquad \text{Eq. (1)}$$

$$ALW_i = \left(\frac{AL_i}{100}\right)(5) \qquad \text{Eq. (2)}$$

AL_i = attainment level of course learning outcome *i* based on actual student performance (%).
SR_i = mean value of student scores in assessment task *j* linked to course learning outcome *i* (%).
n = number of assessment tasks linked to course learning outcome *i*.

ALW_i = attainment level weight value of course learning outcome *i* based on actual student performance (1 to 5).

Student self-perception: The consistency between the actual student performance and student self-perception for a specific course learning outcome *i* is estimated by calculating a corresponding consistency index I_i. The consistency index between the student self-perception and actual student performance for each course learning outcome is calculated by dividing the corresponding average score obtained from the student self-assessment survey of course outcomes by the corresponding attainment-level weight value (Eq. 3). Index values were considered indicative of consistency between results when the error band was in the range of 10% (i.e. $0.9 \leq I_i \leq 1.1$).

$$I_i = \frac{M_i}{ALW_i} \qquad \text{Eq. (3)}$$

I_i = consistency index between student self-perception and actual student performance for course learning outcome *i*.
M_i = mean score pertaining to course learning outcome *i* obtained from the student self-assessment survey of course outcomes.

Effectiveness of the learning approach: Key items of the standard online student course evaluation survey that were related to the effectiveness of the learning approach have been used to reflect student perspectives about the course delivery. Results of the key items have been used to examine how students perceived the course under investigation, which had been designed according to the OBL approach, and to identify whether the teaching, learning activities and assessment tasks were properly aligned with intended course learning outcomes from the students' perspective. A standard of 80% agreement ("agree" plus "strongly agree") or more and a mean score of 4 or more in each item were considered as indicating successful implementation of the OBL approach in the course under investigation.

Limitations

Although the student enrollment in the course under investigation can be considered relatively high for a postgraduate engineering course, 12 students are still a small number of participants from a statistical perspective. The variety of direct and indirect data sources used in the current study are meant to offset this limitation. Although the assessment approach introduced and implemented in the current study is independent of the sample size, further research is needed to confirm its applicability and practicality for classes with higher enrollment. Due to the recognised difficulties and complexity of assessment change, however, starting a trial at the current scope was deemed useful and appropriate (Carless & Zhou 2016). Suggestions for expanding the scope of inquiry are addressed in the conclusion section.

Results

Actual student performance

The attainment levels of CLOs based on the actual student performance are summarised in Table 6. The table shows that all CLOs were adequately achieved. The attainment level of all CLOs, based on student performance, was on average 85%, with a standard deviation of 2% and coefficient of variation of 2.5%. The highest attainment level of 87.4% was recorded for CLO2

and CLO3 (student knowledge and skills, respectively). On the other hand, CLO7, pertaining to student communication skills, exhibited the lowest attainment level, 81.7%. One interpretation is that the use of presentations (the mode of achieving CLO7) should be enhanced or increased.

Table 6. Assessment results based on actual student performance

CLOs	Attainment level based on actual student performance		Level of achievement of CLOs based on actual student performance
	Percent (*AL*)	Weight (*ALW*)	
CLO1	86.6	4.33	Adequately achieved
CLO2	87.4	4.37	Adequately achieved
COL3	87.4	4.37	Adequately achieved
CLO4	85.9	4.30	Adequately achieved
CLO5	83.5	4.18	Adequately achieved
CLO6	85.2	4.26	Adequately achieved
CLO7	81.7	4.08	Adequately achieved
Average	85	4.27	
STDEV	2	0.11	
COV (%)	2.5	2.5	

Consistency index

Figure 3 compares the attainment level weight values of CLOs, based on actual student performance with results of student self-perception, obtained from the student self-assessment survey of course outcomes. The corresponding consistency indices are given in Table 7. While results of student self-perception were generally consistent with actual student performance, students tended to overestimate the attainment level of intended course learning outcomes. This was more evident for CLO7, with a student consistency index value of 1.07.

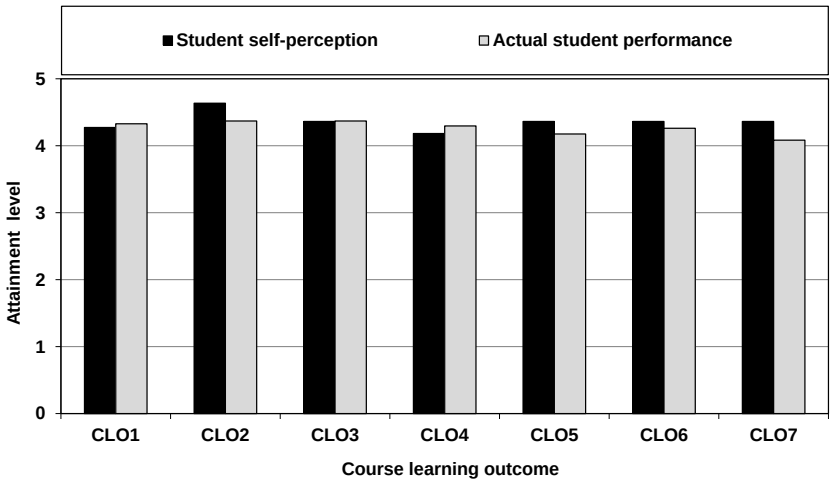


Figure 3. A comparison between actual student performance and student self-perception

Table 7. Consistency indices

CLOs	Consistency index of student self-perception	
	Index (*I*)	Observation
CLO1	0.99	Consistent
CLO2	1.06	Consistent
COL3	1.00	Consistent
CLO4	0.97	Consistent
CLO5	1.04	Consistent
CLO6	1.02	Consistent
CLO7	1.07	Consistent

Students' judgements about their achievement depend on their level of understanding of assessment requirements and how their performance would be evaluated against these requirements (Wesp et al., 1996). That student and instructor judgements of student performance tend to vary is well-established (Boud & Falchikov 1989; Brown & Harris 2014). Students in this study overestimated their level of attainment of course learning outcomes possibly because they were not given an opportunity to evaluate their own work against reference criteria/standards. Involvement of students in the application of a marking rubric to a sample assessment output could result in a better consistency between student and instructor assessment. Providing students a range of exemplars of high-, medium- and low-level student work may help students to better understand the requirements of assessment (Cowan 2002, 2006). Engagement of students in self- and/or peer-assessment tasks may improve their self-evaluative capacity and expertise (Carless 2015). Closing this judgment gap and fostering in students the capacity to more accurately judge their own work would have the additional benefit of developing a recognised sustainable competency through engagement with assessment (Boud & Soler 2016).

Online student course evaluation survey

The mean scores of the key items of the online student course evaluation survey and frequency charts are shown in Figures 4 and 5, respectively. All items achieved an agreement level ("agree" plus "strongly agree") greater than 80% and a mean score ≥ 4, which confirmed students' perception of successful implementation of the OBL in delivering the course under investigation.

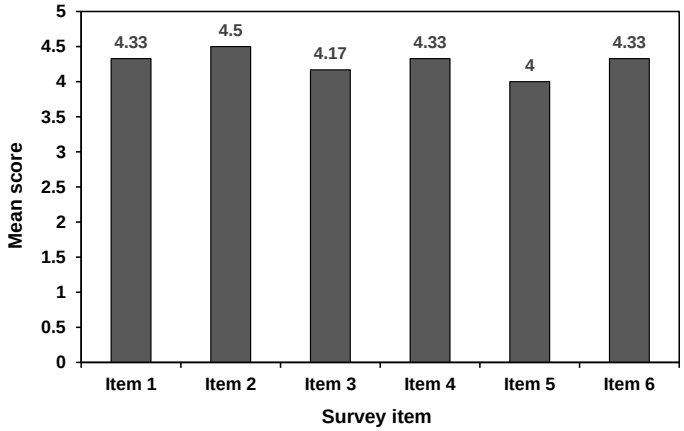
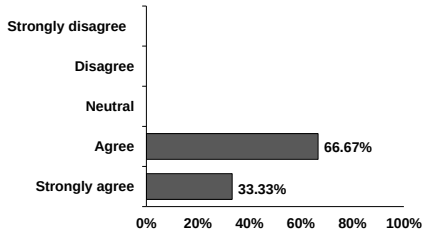
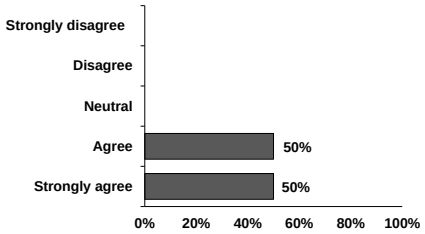


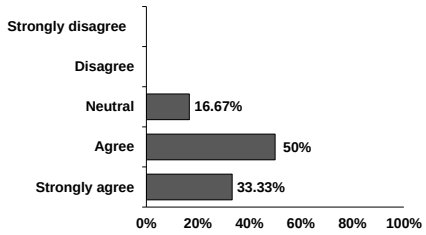
Figure 4. Mean scores of the key items of the online student course evaluation survey



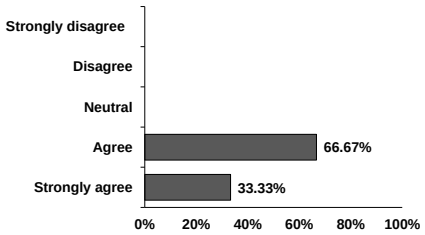
1. The course [outcomes] were clearly explained.



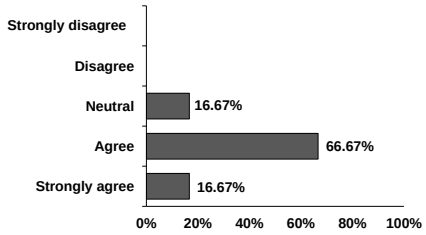
2. There was close agreement between the stated course [outcomes] and what was actually covered.



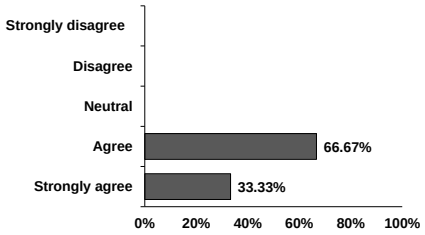
3. Evaluation methods were clearly explained.



4. The assignments in the course were clearly related to the course [outcomes].



5. The general climate in this course was good for learning.



6. The course added to my knowledge in my major

Figure 5. Frequency charts of the key items of the online student course evaluation survey

Discussion

A key finding was the confirmation of the feasibility of adopting OBL in a postgraduate civil-engineering course. A related finding was the validation of a revised and innovative assessment approach for promoting and determining outcome achievement. Findings demonstrated how assessment tasks can function within an OBL framework and meet benchmarks of innovation. These include performing the double duty of developing and demonstrating achievement, as well as the twin purposes of addressing immediate learning priorities while still developing graduate competencies (Boud & Falchikov 2006; Boud & Soler 2016). One implication is that an OBL initiative and assessment innovation may compliment each other when implemented together, as they may provide a balance of priorities while reducing the threat of reification through OBL (Ewell 2005) and resistance to assessment change (Deneen & Boud 2014).

Results also provided insight into areas for improving learning engagement and assessment. The student feedback to item 6 of the online student course evaluation survey indicated that students appreciated the value of the course under investigation. All students agreed that the course *added* to their knowledge in their major. This confirmed the concept of using learning as development (Ewell 2005). Although the attainment level of CLO7, pertaining to student communication skills, was above 80%, it was the lowest of all elements. This suggests that in future semesters, students should deliver multiple presentations throughout the delivery of the course to further improve their communication skills. Although the agreement levels and mean scores of items 3 and 5 of the online student course evaluation survey were acceptable, about 17% of the students were uncertain about the clarity of the evaluation methods and the quality of the learning environment. More attention should then be given to these items in future semesters. Evaluation methods should be repeatedly explained to students throughout the delivery of the course. This validates the idea that undertaking an OBL and/or assessment initiative should be accompanied by a component requiring diligent research (Deneen et al. 2013; Deneen & Boud 2014). This can provide insight into ongoing improvement, and may therefore play a significant role in properly positioning OBL and assessment innovation within a broader QA/QE context.

Conclusion

Results of the current study confirmed the feasibility of adopting OBL in a postgraduate civil-engineering course when accompanied by innovative assessment practices. The implemented assessment practices provided support for and evidence of student learning. This strongly suggests that there was a valuable engagement. A constructive alignment of the analysis of student results in assessment tasks with intended outcomes provided direct evidence of student attainment of learning outcomes. Students' perceptions of their own attainment of learning outcomes was generally consistent with their actual performance in the direct-assessment tasks. Only the results of item 6 of the online student course evaluation survey could indicate whether *value-added* learning occurred. From a quality-assurance standpoint, both attainment and development may be important. This study contributes to research suggesting that evaluation of students should be crafted more specifically to the frameworks and intentions of change and innovation (Deneen et al. 2013). Using fine-tuned instruments more sensitive to OBL and assessment innovation, future studies might produce more varied and differentiated evidence for the impact of these innovations in a higher-education context.

Similarly, gathering evidence of students' perceptions of the OBL experience and their achievement proved meaningful. First, it demonstrated that students tended to overestimate their level of attainment of learning outcomes. Closing this gap is an area of extraordinary importance to the development of sustainable assessment practices by institutions and sustainable competencies in students (Boud & Soler 2016). Thus, it would be productive to pursue this point through further trials within the context of developing an OBL approach to assessment. Second, this demonstrates the importance of collecting perceptual data as part of an assessment-change initiative. Stakeholder perceptions matter in terms of the success of assessment initiatives (Bromage 2006; Deneen & Boud 2014; McInnis 2006; Trowler & Bamber 2005). As this initiative expands to include other instructors and disciplines, this specific line of inquiry should be expanded to include student and instructor perceptions.

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