Innovative Industry Engaged Project-Based Learning for Civil Engineering Structural Design

Natalie Lloyd[a] ; Kerri Bland [a].
Curtin University, Corresponding Author Email: n.lloyd@curtin.edu.au

CONTEXT

An innovative shift undertaken in a third year structural design unit (concrete and steel design) was implemented in 2013. This shift aligned with a University-wide transformation of learning to reduce or replace lecture contact time and move learning to active, student-centred workshops. Coupled with the transformation was the introduction of two industry-engaged design projects for team-based learning and assessment tasks. The initiative required the commitment of staff to re-align teaching and redevelop teaching materials, and design and implement new learning activities, feedback and assessments. This paper reflects on the initial and subsequent current iteration.

PURPOSE OR GOAL

The introduction of student-centred workshops and projects for team based learning sought to increase student engagement and improve students' competencies in communication skills and engineering application ability, in line with the University's graduate attributes and Engineers Australia Stage 1 competency standards. Whilst all teaching staff have extensive design and construction experience in industry it was felt that current practitioner involvement would enhance the relevance of the learning experience and provide students with access to professional engineering role models. The exposure to sponsoring engineers and a realistic client brief was anticipated to be beneficial to students' motivation, development of technical skills and professional skills.

APPROACH

The industry-engaged projects were presented as design-briefs by the industry-partners only after a significant period of consultation and development of the briefs with teaching staff to ensure the design briefs would facilitate student learning, align with content resources, and enable students to demonstrate unit-learning outcomes. Student teams conceived, designed and presented their solutions to the design briefs within the workshops. The industry collaborators benchmarked students' design solutions against the 'real-life' implemented solution for the projects. Lecturing staff consciously withdrew from decision making roles in the teams as a means of strengthening the teams' technical and design process skills. Lectures were reduced or replaced by online video mini lectures.

OUTCOMES

The outcomes of the initiative have been assessed evaluating qualitative and quantitative feedback from students using the University-wide student survey system and reflective practice of the industry-partners, lecturers and sessional staff. It was found that students engaged with the project based learning activities and assessments, and valued their contribution to their learning and future career as engineers. However, many students resisted the change to project-based learning, reduced lecture hours and the shift to a more autonomous learning environment.

SUMMARY

Review of unit activities has been undertaken and modifications have been implemented in the 2014 offering. Results from the second iteration will be available by the conference date. We anticipate improved student feedback as we refine and streamline the unit activities to better suit student expectations and have a cohort in 2014 who is more familiar with a mixed mode of delivery. This paper presents a frank exploration of student feedback to an innovation.

KEYWORDS

Structural design, project-based learning

Background

This paper reflects on the transformation of a core third year unit in a Civil and Construction Engineering Degree. The transformation included teaching delivery and implementation of industry-engaged authentic design assessment tasks. This paper reflects on the initial execution and feedback, suggests areas for improvement and updates on the latest iteration of the innovation in 2014.

An innovative shift undertaken in a third year structural design unit (concrete and steel design) was implemented in 2013. Teaching content-delivery was radically transformed with an overall 50% reduction of lectures, with some lectures completely shifted to on-line, coupled with the introduction of two hour workshops with maximum class sizes of 40 with staff of up to 4. This shift aligned with a University-wide transformation of learning to reduce or replace lecture contact time and move learning to active, student-centred workshops with a more flexible, mixed mode of delivery. This transformation of delivery relied upon University structural support such as timetabling, infrastructure and workload flexibility. The University driven transformative initiative required the commitment of staff to re-align teaching delivery and redevelop teaching materials, and design and implement new learning activities, feedback and assessments. Most academics engaged in the transformation in engineering and science therefore reported concerns with increased workload. However, staff also reported an improvement in student engagement, increased student responsibility and increased attendance (Appleton et al, 2014).

Coupled with, and indeed, fundamentally aligned with the transformation of teaching practices was the introduction of two industry-engaged design projects for team-based learning and assessment tasks. The industry-engaged projects were presented as design-briefs by the industry-partners and completed by student teams in collaboration with industry partners. Assessment included team assessment of professional skills including communication and creativity in design. All learning outcomes and feedback rubrics were aligned with Engineers Australia Graduate Competencies and University Graduate Attributes.

Purpose

The industry-engaged projects were implemented with the purpose of providing students with opportunities to engage in authentic design tasks, collaborate and engage with industry partners, and develop greater employability through enhanced communication and team work skills. The purpose was to use student centred workshops as a collaborative, team-based environment in which students controlled the workshop activity and level of engagement with staff which included industry advisors, lectures and sessional staff, all of whom were chartered engineers currently employed in the industry. The purpose of on-line content delivery was to enhance engagement with technical material in a familiar and accessible medium, allow self-paced access to lecture content and student autonomy.

Approach

Project Design– Industry and Cross Disciplinary Engagement

Two industry-engaged design projects for team-based learning and assessment were significantly valued and worth 50% of the unit assessment. The project based tasks were aligned with learning outcomes of the unit, Engineers Australia (EA) Graduate Competencies and University Graduate Attributes. As part of the revision of teaching practice, detailed feedback and assessment rubrics were developed in 2014 articulating in greater detail the connectivity of the task and assessment to EA Competencies as seen in Table 1 which shows an extract of the marking rubric for the industry-engaged project for concrete design. Detailed descriptors, particularly for those of oral or written communication, were

benchmarked against international standards; the Common European Framework of Reference for Languages. This required cross disciplinary collaboration with the University English development specialists within Teaching, Learning, and Assessment.

Table 1: Extract from Assessment and Feedback Rubric for One Element of Report

Item	Engineers Australia ULOs	Excellent standard	Moderate Standard	Below standard	% of assessment
REPORT: ACADEMIC WRITING – Communicating the outcomes of the brief	3.2. Communication 3.3. Creativity 3.6. Team work **ULO 3**	Writing shows use of an extended grammatical range that is error-free. Spelling is accurate, and writing is clear and smoothly flowing. The text is well-structured and shows controlled use of a wide range of sophisticated organisational patterns, connectors and cohesive devices.	Consistently maintains a high degree of grammatical accuracy; errors are rare and difficult to spot. Spelling is accurate, apart from occasional minor errors. Writing is clear and smoothly flowing to produce a well-structured text, showing controlled use of a medium range of organisational patterns, connectors and cohesive devices.	Shows good grammatical control. Minor errors in sentence structure may occur, but they are rare and do not lead to misunderstanding. Spelling and punctuation are reasonably accurate but may show signs of other-language influence. Uses a limited number of linking words to create a clear, coherent text, marking the relationships between ideas, although some disjointedness occurs in longer pieces of writing.	10

Project Delivery – Industry and Student Engagement

The industry-engaged projects were presented as design-briefs by the industry-partners only after a significant period of consultation and development of the briefs with teaching staff to ensure the design briefs would facilitate student learning, aligned with teaching resources, and enable students to demonstrate unit-learning outcomes. The alignment of the project-based tasks with the instructional syllabus was a key challenge faced by the teaching staff and is a challenge documented by others involved in project based learning transformation of curricula and assessment (Dahm and Anderson, 2013).

Whilst all teaching staff has extensive design and construction experience in industry it was felt that current practitioner involvement would enhance the relevance of the learning experience and provide students with access to professional engineering role models. The exposure to sponsoring engineers and a realistic client brief was anticipated to be beneficial to students' motivation and development of technical skill. This has been reported in other research where interactions with company sponsors strengthened a sense of identification

with the project objectives for motivated teams (Delson, 2001). The industry partners also provided extrinsic motivation for design team excellence, this reward being financial or one-to-one mentoring for final year honours projects for the top teams' members. Additional technical and mentoring support was provided by industry active engineers. These current engineers provided students with role models for professional communication, problem solving and engineering systematic use.

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Content Delivery – Video Lectures

The delivery of lecture content; the theory and application of design and modelling of design solutions, was anticipated to be accessible and promote engagement with the content as has been demonstrated in other disciplines aligned with engineering, such as mathematics (Taylor and Galligan, 2006; Niess and Walker, 2010; Dawson and van Loosen, 2012). It can be argued however, that engagement is likely for a motivated student regardless of the mode of delivery and this has been found in other cohorts where a positive attitude to web based delivery aligned with a positive attitude to the subject matter (Dawson and van Loosen, 2012). The lecture videos were of maximum length 15 minutes with an average below 9 minutes presented in mp4 format.

Results

Industry Based Authentic Design - Reflection

The first 2013 industry-engaged project was a steel portal frame for an ore-handing facility and the second industry-engaged project was a reinforced concrete building extension for an office and goods storage facility. In 2014 the projects have been similar but with some new industry partners drawn from the wider Engineering Industry Engagement project in the Faculty of Engineering. All industry partners from 2013 have remained engaged with the University and provided industry-based projects for other units. The wider Engineering Industry Engagement project enabled a broader pool of industry partners to be accessed and alleviated the reliance on the goodwill of a small pool of industry-partners. This is seen as advantageous for sustainability of industry based projects.

Student teams conceived, designed and presented their solutions to the design briefs. The teams were given formative and evaluative feedback. For the Concrete Project they had two evaluative feedback interim milestones to achieve; a progress report (5%) and a draft written report (5%) before submission of the final written report (25%). For the Steel Project students had formative feedback in workshops prior to the final oral presentation to the teaching staff, peers and industry sponsor (15%). This process was perceived as best

practice however, it was disappointing to note that formative feedback was often disregarded it the final presentations and reports suggesting the value students placed on formative feedback was low or the feedback timing was not adequate to allow for student reflection and implementation.

The industry collaborators for the projects benchmarked students' design solutions against the actual 'real-life' implemented solution for the projects. Online discussion boards and group online interactivity tools were enabled in 2014 to widen the opportunity for discussion outside the Workshop times. Feedback in the workshops in 2013 was limited to provision of technical and project management expertise. Lecturing staff consciously withdrew from decision making roles in the teams as a means of strengthening the teams' technical and design process skills which may also serve to increase team motivation (Delson, 2001). Criticism was received from students on this strategy with comments reflecting the perception that the design based projects, whilst practical, were dissimilar to previous assignments and too open-ended.

Group Selection and Assessment – Feedback and Reflection

Assessment criteria addressed the functionality of the student teams including professional skills of communicating, documenting design and decision making processes and conflict resolution. A team-related measures matrix was used for the assessment of team efficacy. It rated individual and team contributions based on documented behaviours and outcomes Students were assigned groups for the steel project and were allowed self-selected groups for the concrete project. Some research indicates that self-selected groups report lower efficiency and higher conflict. However, self-selected groups can be a good simulation of 'real-world' working groups rather than randomly assigned groups. Self-selected groups tend to have a composition of persons who know each other plus others and add value to the students' experience of group work (Chapman, Meuter, Toy and Wright 2006). It has been shown that students learn more from good team experiences than they do from bad ones so teaching staff endeavoured to place students in team situations with the greatest chance for success (Bacon, Stewart and Silver 1999).

Areas for further improvement have been identified including greater team training and maximising team longevity. The implementation of a structured group process plan may help in addressing anticipated and unforeseen challenges in group work (Igbo and von Baggo, 2013). Strategies to address this have been adopted including implementation of team training including workshops in group conflict resolution and team roles in core second year units. Negative feedback was received on the students being assigned groups and the workload as reflected in the comments below; however, the majority was positive feedback on the use of group assignments with the qualifier that workload should be reduced as it was perceived as excessive.

30% is too much for a group assignment, especially given the fact that as the only person in my group for whom English is not a second language I ended up with the majority of the workload.

I prefer individual assignments but the group concept was a good one.

Group project is good for us to gain practical understanding. However, workload is heavy.

Innovation - Student Feedback

The outcomes of the initiative have been assessed in 2013 evaluating qualitative and quantitative feedback from students using the University-wide student survey system and reflective practice of the industry-partners, lectures and tutor. It was found that students engaged with the project based learning activities and assessments, and valued their contribution to their learning and future career as engineers, with comments provided such as:

The workshops were particularly helpful. I liked the idea behind the assignments being industry based.

The workshops are very beneficial. I enjoyed the steel assignment.

The assignment tasks were useful and helpful in learning what the real life design work would involve.

The reports and presentations really help a lot to prepare students for their future career.

Design Project is very helpful for a better understanding in structural design.

It resembles real world structures designing, which is a good application towards our future job prospects.

The design project is useful to understand the actual concept of designing so that our design could be more practical.

The assessments allowed a more practical experience and are preparing us for future units/thesis.

However students resisted the change to project-based learning, reduced lecture hours and the shift to a more autonomous learning environment. Many comments reflected a desire for the traditional lecture delivery, traditional structured tutorial with exemplar solutions, and reduced workload. Statics tracking of access and feedback from students indicated that online mini-lectures were rarely accessed prior to the Workshops session which was contrary to staff expectations. The negative feedback received from students related to a belief that lecturers were not providing 'value for money' or sufficient 'teaching'. Additionally it was perceived the reward of students who had achieved was inequitable and disadvantageous to students who had not achieved.

It seemed as though the lecturers didn't really want to teach us anything and instead left us with these assignments to find our way through, which is a poor academic strategy.

We have all paid the unit fees and in this instance feel that I been cheated.

Too much mini lectures which means we just need to learn by ourselves instead of going to class

Get rid of the workshop concept. It's a waste of time as it requires all students to grasp the concept of the items taught in class prior to the workshop which is not always the case.

we were expected to know theory off of 1 lecture, which is ridiculous when we are paying 1000$ to get taught something, why do i need to attempt to understand everything off of 1 very poorly delivered lecture a week, which covered hardly anything. Bulk of my learning was me doing it all myself, may as well have not had any lecturers.

Overall satisfaction rating for the unit dropped to below acceptable levels and has needed to be addressed. This has occurred in 2014 with a shift in emphasis on the projects as the learning activity for the Workshops. In 2014, workshops were more structured to provide a practice environment in which students mastered the content. The industry projects were primarily completed in students' own time, and online support was provided along with face to face time in workshops. Additionally, no assessment was conducted in workshop time, thus reducing the impact on student access to industry partners and lectures for assistance. Extra mentors for the Workshops were provided who had extended design experience and current engineering roles in industry, in addition to lecturing experience.

Conclusion

Review of unit activities has been undertaken and modifications were implemented in the 2014 with greater structuring of the Workshops and removal of all assessment from the Workshop time. Some lectures were reintroduced for parts of the unit which in 2013 were replaced entirely by online lectures. The structuring of Workshops enabled more opportunity for student mastery of design concepts and practice before immersion into project based work which was being assessed. Results from the second iteration will be available by the conference date. We anticipate improved student feedback as we have responded to some feedback and reflected upon our practice. An additional consideration to be taken when reviewing the feedback is the degree of familiarity with mixed mode delivery and project based learning. The 2013 third year cohort were unfamiliar with this teaching and learning delivery mechanism. The current 2014 cohort have had the benefit of a previous four units in both Structural Analysis and Structural Design in which mixed face to face and online lectures work in conjunction with extended Workshops and problem solving based activity to achieve learning outcomes. Their expectations may be better aligned with those of academic staff, Engineers Australia and the University.

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