Introduction

"Integrated Design Project" (6003ENG) is a final year capstone course as part of the civil engineering program offered by the Griffith School of Engineering, which integrates and builds on several other courses covered in preceding years. The main focus of this course is to encourage students to reflect and apply the knowledge and concepts learned in their degree to solve real world structural and civil engineering problems through a major design project. On average there are about 150 students enrolled in the course. The course is taught by industry engineers as primary lecturers, guest lecturers and tutors. The course coordinator represented by a Griffith University academic staff appoints and coordinates the industry engineers and works closely with them to create the best possible student learning environment and achieve the critical learning outcomes.

Background

By nature, this course is fundamentally challenging. A number of issues have become evident over the last few years of offering based on feedback from teaching staff and students. The students are not exposed enough to real life design project through the first few years of their degree and typically face difficulties in project-based learning when more than one solution is correct. The performance and the learning experience of some students are also affected by their prior knowledge on the fundamental courses covered in the previous years. Even though the course is taught by very experienced practising engineers, their teaching approach is usually not compatible with that of academic staff. The overall organisation of this course is also somewhat less effective due to the involvement of the external lecturers. Due to these reasons, the students were usually not appreciating the course and the way it was delivered. This led to poor student learning experience and hence low course evaluation scores in the past. This paper will discuss the proposed redesign strategies based on education theories and principles available in the literature. It will also present the outcomes, student feedback and future recommendations to continuously improve the course for the future offerings.

Integrated Design Project – The Course

This course incorporates all the elements of civil engineering program including structural, water and geotechnical engineering and construction and project management. The relationship of this course with other fundamental engineering courses covered in the Civil Engineering program at Griffith University is presented in Figure 1. The course is covered within the stipulated 13 weeks of teaching in one semester. Weekly, the teaching constitutes 2 hours of lectures and 2 hours of tutorials.

The design project of this course entails the development of the students' generic and technical skills and the ability to integrate all phases of a design project. The ultimate goal of the design project is to produce a detailed design of the specified building structure incorporating all aspects of civil and structural engineering design. The design project was also selected in such a way that there are combinations of different structural types/elements. This allowed group comparison which has helped students better understand the performance of different designs. To ensure timely completion of the assignment, a set of benchmarks (structural deliverable 1, structural deliverable 2 and civil deliverable) were established. At each benchmark, students were required to submit all necessary calculations and drawings with detailed discussions.

The student performance was assessed according to the breakdown shown in Table 1 for 2013 - 2015. The structural deliverables involve the design of key structural frame elements of a building including slabs, beams, columns and shear walls (structural engineering). The civil

deliverables involve approvals process (construction and project management), earthworks / site grading and pavement design (geotechnical engineering), and stormwater drainage network, sewer and water connection design (water engineering). Specifically, the project assesses problem identification, formulation and solution, analysis and critical evaluation. Two communication letters are individual assessment items, designed to place students in a design office situation and to develop their skills in writing appropriate letters to (1) offer service to a client and (2) request service from a subcontractor. The aim of the final exam is to test students' overall understanding of the course, as well as their understanding of engineering problems taught by the guest lecturers.

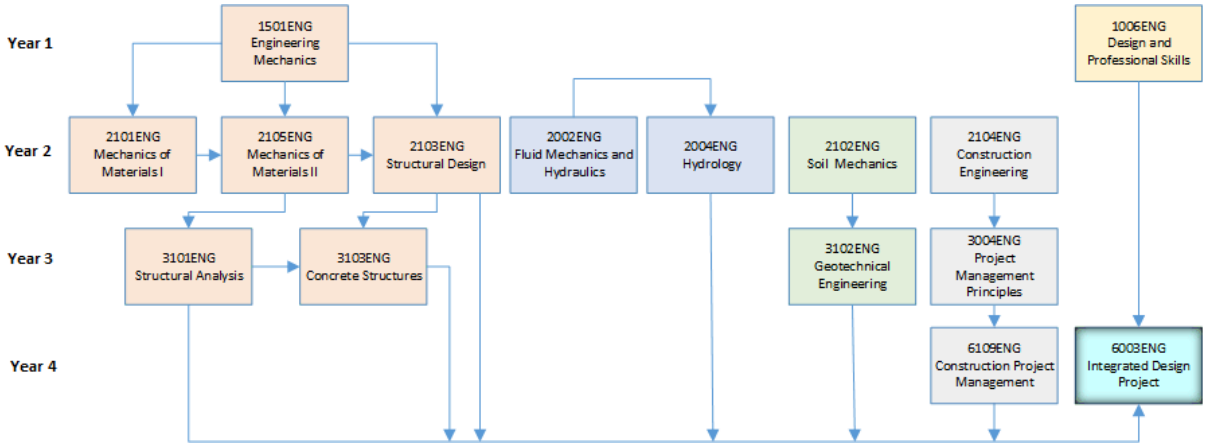

Figure 1: Integrated design project in civil engineering program

Table 1: Assessment summary

Assessment Task	Weighting		
	2013	2014	2015
Communication letters	5% (Individual)	10% (Individual)	10% (Individual)
Civil deliverable	25% (Team)	40% (Individual)	25% (Team)
Structural deliverable 1	25% (Team)	25% (Individual)	15% (Team)
Structural deliverable 2		25% (Individual)	20% (Team)
Final Exam	45% (Individual)	-	30% (Individual)

Redesign of Course

In 2015, the course (Integrated Design Project - 6003ENG) has been redesigned to improve its quality and delivery. Major changes are introduced in regards to the teaching team, learning activities and assessments & weightage. The assessment plan of similar third year course (Civil Engineering Design Project - 3113ENG) was considered for internal benchmarking (Table 2). The course content and assessment plan of similar final year courses offered by other universities (Design of Concrete Structures and Foundations - ENB471 by Queensland University of Technology and Civil Design 1 - CIVL4514 by University of Queensland) were also considered for external benchmarking (Table 2). All these final year courses are project based courses delivered mainly by professional engineers.

Table 2: Benchmarking with similar courses offered by other universities in the region

University of Queensland		Queensland University of Technology		Griffith University			
ENB471 - 4th Year		CIVL4514 - 4th Year		6003ENG - 4th Year		3113ENG - 3rd Year	
Workbook	10% (I)	Structural design 1	20% (T2)	Communication	10% (I)	Land use analysis	30% (T4)
Structural design 1	25% (T1)	Structural design 2	50% (T2)	Structural deliverable 1	15% (T3)	Self & peer assessment	5% (I)
Structural design 2	45% (T1)	Final exam	30% (I)	Structural deliverable 2	20% (T3)	Road geometric design	10% (I)
Final exam	20% (I)			Civil deliverable	25% (T3)	Drainage design	10% (I)
				Final exam	30% (I)	Final exam	45% (I)

Note: I - Individual work; T1 - Team work with 4-5 members; T2 - Team work with 5-6 members; T3 - Team work with 2-3 members; T4 - Team work with 4 members.

The changes were discussed with previous coordinators and structural academic staff to ensure all course aims and learning outcomes had been appropriately addressed. The major changes were reviewed by the Moderator, Head of Discipline and the Head of School. The improved course was also reviewed by the School of Engineering Focus Group, led by the Deputy Head of School (L&T). Student feedback was relayed to the Course Coordinator and the feedback from the Deputy Head of School (L&T) was addressed.

It is expected that the students' learning experience will improve with this redesign while achieving the critical learning outcomes. The purpose of this study is to collect evidence on the redesign of this course in improving students' learning experience and their overall performance in the course.

Approach

The major changes made in 2015 are,

1: The best teaching team was developed by identifying the industry engineers who can encourage students to take the deeper learning approach.

The teachers' beliefs about learning (Richardson 2005), their beliefs about intelligence and their approaches to teaching (Trigwell 1994 and Richardson 2005) will influence the students' approach to learning. Therefore, it was critical to form the best teaching team which will direct students to take a deeper approach to learning (Heney 2014). Many of the industry engineers are not used to university teaching and one alternative is to use an academic who has industry experience. However, it felt more appropriate to the teaching team if practicing engineers teach this subject using real world problems and projects. It is also critical for Griffith University to produce work-ready graduates. Therefore, practicing engineers with teaching qualities were selected after carefully analysing their previous students' feedback, when available. The teaching team also had a meeting before the semester to discuss the ways to improve their teaching qualities.

2: Coordinator helped the students with technical questions when the students are extrinsically motivated during submission weeks.

Students can be motivated intrinsically and extrinsically (Ormrod 2014, GradCert HigherEd 2015, Sylvia 2011) and they are normally extrinsically motivated during assignment submission weeks to achieve a higher grade. Unlike other weeks, during this time they spend more time to study and go through the experiential learning cycle where the leaner do, think, conclude and adapt. During these weeks the students are self-directed and their learning is in a networking process as explained by the connectivism theory (USC Blended Learning 2014). In the past, the coordinator was not available for technical questions and the engineers were not accessible outside the lecture times due to their own work commitments. Hence the students were not supported properly during these weeks and they have to wait until they see the engineers in lectures and tutorials. This reduced their motivation to learn and many took a surface approach to learning. An approach used in the past was that students emailed the coordinator with any technical questions and the coordinator forwarded their email to the industry engineers who then answered the questions through emails. This is not the best way to help students learn while they are extrinsically motivated. Hence this year it was proposed that the coordinator should be available for technical questions.

3: Intrinsically motivated students with challenging design projects

In the past a rectangular shaped building with uniform column layout was considered in their design project. However, this year the industry engineers were asked to use a building with irregular shape and column layout which is very common in the design industry. It was found that this challenging project intrinsically motivated the students to take a deeper approach to learning (Heney 2014).

4: Reduced the class size and encouraged active learning

The physical space is a key factor which influences students' learning (Lippman 2010). In the past all of the 150 students were allocated to a single tutorial where they had minimal interaction with the lecturer. This year it was proposed to divide the tutorial class into two so that there will be 75 students in each class which will encourage active learning with more lecturer-student and student-student interaction (NWIACommCollege 2011, Pelly 2014 and Prince 1994). The limitation of this major change is that there were still too many students in one tutorial class.

5: Understand the students' prior knowledge, eliminate the fear of failure and encourage them to learn (reflect) from mistakes

Students' prior knowledge (Ambrose and Lovett, 2014) which is important for their critical learning process varies considerably for this course. Hence the performance and the learning experience are affected by students not remembering or mastering the prior knowledge covered in the previous year's fundamental courses. This led to the fear of failure which had detrimental effect on their learning (Science Daily 2014). Hence the previously learned concepts were briefly revised in this course and the students were encouraged to get regular feedback from engineers before submitting their final reports, where they can try and learn from mistakes (reflect).

6: Encouraged collaboration and active learning through team work

Even though the students worked as a team in the past, the students were asked to submit their report individually in 2014. However, this year they were asked to work in a team (of 2-3 members) again so that they can collaborate (Cabrera et al. 2002). This will also encourage active learning (Pelley 2014) with more student-student interaction. The limitation of this major change is that the group work was not individually assessed which will be rectified in the next offering.

7: Maintained optimum level of stress with quality assessment techniques

The assessment practices influence the learning approaches (Scouller 1998). In 2014, the final grade was based on the individual project report and there was no final exam. This lead to surface learning approach and hence this year the final exam was re-introduced to discourage this. This is also good in a way to retain their memory using the concept called "spacing" between assessments (Gocognitive 2012 and Carpenter 2014). Schwabe and Wolf (2009) suggested that stress may impair memory. However, it was found that the optimum level of stress could be achieved by having an open book final exam in this course which enhanced attention with improved student performance.

Results and Discussion

Students' Performance

The students' overall performance for this course is shown in Table 4 for 2013 - 2015. The standard of this course has been maintained in 2015 with real world project (more challenging than in previous years) and final exam. Compared to last year, Grades 7 and 4 are reduced this year by 6-7% with more students achieving Grades 6 and 5. Failure rate is very similar to previous years (2013 and 2014). In 2015, 22.1% students could have achieved Grade 7 if there was no final exam. This dropped to 9% when considering the final exam and allowed to clearly identify students who mastered the course and not played a passive role during the team work project. However, it was found that the failure rate was not affected by the final exam. The students' performance in this course was compared to the 2014 results of 3113ENG, a third year course which mainly included the same student cohort in 2014, as a benchmarking process. The results were found to be consistent in regards to the percentage of students who achieved Grade 7 (9.0% and 7.2%) and the failure rate (3.3% and 8.3%).

Table 3: Overall student performance

Course	Year	Final Exam	HD/7	D/6	C/5	P/4	F	Other
6003ENG	2015	Yes	9.0%	36.1%	27.0%	18.9%	3.3%	4.9%
		If excluded	22.1%	32.8%	23.8%	17.2%	4.0%	-
	2014	No	16.3%	29.7%	25.6%	25.0%	2.4%	1.2%
	2013	Yes	6.0%	20.7%	22.7%	32.7%	2.7%	15.3%
3113ENG	2014	Yes	7.2%	22.7%	35.4%	26.5%	8.3%	-

Learning experience

The outcome of the redesign has been evaluated using **PMI** (Plusses, Minuses and Interesting) survey in Week 5 and regular discussions with students during the semester. The PMI was developed by Bono (2009), and this technique can be used to evaluate the ideas which were already developed by brainstorming (Baer et al. 2012). The PMI survey results also indicated a few issues with the overall course management which was rectified after Week 5. The outcome of the redesign was further validated by an extended **SEC** (Student Evaluation of Course) survey with formal student evaluation and qualitative feedback at the end of semester (Weeks 12-14). The qualitative and quantitative students' feedback are summarised in Tables 4 – 6. In Table 5, Q1-Q6 are standard questions in the formal feedback process by Griffith University and Q7-Q9 are specifically added to evaluate the students' learning experience of this course.

Table 4: Qualitative feedback from students in 2015

Plusses & Interesting (PMI Survey). What did you find particularly good about this course? (SEC Survey).	**Minuses (PMI Survey). How could this course be improved? (SEC Survey)**
Relevance to real world practice [PMI = 22 and SEC = 23]	Clarification of assignment [PMI = 10 and SEC = 13]
Quality of the lecturers [PMI = 18 and SEC = 15]	Complexity of examples versus assignment [PMI = 9 and SEC = 9]
Applicability of previous learning [PMI = 12 and SEC = 5]	Late night classes [PMI = 12 and SEC = 6]
Internal help from Griffith staff [PMI = 9 and SEC = 6]	Quality of the lecturers [PMI = 9 and SEC = 5]

Note: PMI - Number of students with similar comments in PMI survey; Number of students responded in PMI survey = 44; SEC - Number of students with similar comments in SEC survey; Number of students responded in SEC survey = 71.

Table 5: Quantitative feedback from students in SEC survey, 2015

Question	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**
Score (/5)	3.7	3.4	4.0	4.1	3.9	3.8	4.3	4.0	4.0

Note: Q1 - This course was well-organised; Q2 - The assessment was clear and fair; Q3 - I received helpful feedback on my assessment work; Q4 - This course engaged me in learning; Q5 - The teaching (lecturers, tutors, online etc) on this course was effective in helping me to learn; Q6 - Overall I am satisfied with the quality of this course; Q7 - This course required me to apply, reflect upon, and integrate my University learned knowledge and skills in an industry or professional setting; Q8 - The group work helped me to learn; Q9 - The internal technical support from coordinator for the structural assignments in this course assisted my learning.

Tables 4 and 5 show that the students have appreciated the fact that the course required them to apply, reflect upon, and integrate their University learned knowledge and skills in an industry or professional setting. This is quantitatively verified in Table 6 (Score of 4.3/5 for Q7). Students also valued the group work which enabled them to learn in a collaborative environment (Score of 4.0/5) and the internal technical support from Griffith academic (Score of 4.0/5). As shown in Table 7, significant improvement in student evaluation of the course (SEC scores) was recorded this year after the redesign of the course. However, it should be noted that the students raised concerns regarding the clarification and support on the design project (Tables 4 and 5) which is quantitatively verified in Table 6 (Score of 3.4/5 for Q2). This will be considered in the course improvement plan for the next offering.

Table 7: Student evaluation of the course based on Q6

Year	**Survey**	**Score (/5)**	**Strongly Agree (5)**	**Agree (4)**	**Neutral (3)**	**Disagree (2)**	**Strongly Disagree (1)**	**Response Rate**
2015	SEC	3.8	31.4%	35.7%	20.0%	7.1%	5.7%	71 of 121
	PMI	3.6	9.1%	47.7%	34.0%	9.1%	0.0%	44 of 121
2014	SEC	3.2	21.6%	25.5%	17.6%	21.6%	13.7%	51 of 172
2013	SEC	3.3	10.1%	42.0%	23.2%	15.9%	8.7%	69 of 148

Conclusion and Recommendation

Integrated Design Project is a final year capstone course, which integrates and builds on several other courses covered in preceding years as part of the civil engineering program offered by the Griffith School of Engineering. The course is taught by industry engineers as primary lecturers, guest lecturers and tutors. By nature, this course is fundamentally challenging and the students were usually not appreciating the course and the way it was delivered. This led to poor student learning experience and hence low course evaluation scores in the past. Recently, the course has been redesigned to improve its quality and delivery. The redesign considered several learning theories and principles identified and developed in the literature. The outcomes of this study were validated by an extended survey in Week 5 and, formal student evaluation and qualitative feedback at the end of semester. It was found that the students' learning experience has improved considerably with this redesign while achieving the critical learning outcomes. Based on student feedback, detailed course improvement plan will be developed with recommendations to continuously improve the course for the next offering.

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