Full Paper

Introduction

Central Queensland University (CQU) offers two unique degree pathways in engineering – one requiring Co-op experience (the dual award program Bachelor of Engineering (Co- operative Education)/Diploma of Professional Practice (Engineering) (Jorgensen and Howard, 2005a)) and one with a Distance Education option, but no Co-op option (Bachelor of Engineering). Approximately 27% of the CQU enrolled engineering students (19% EFTSL) take their courses as part of the distance education program. Both of the degree options

integrate Project Based Learning (PBL) in all years of the degree program (Howard and Jorgensen, 2006).

While the learning benefits of cooperative learning and teamwork are well documented (Springer et al., 1999), assessing the learning of individuals that contribute to a team project remains a challenge. As described in Eliot et al. (2012), students, instructors and accrediting bodies are still grappling with determining which assessment tools are most appropriate to determine an individual grade in a team setting.

Portfolios are one approach used to assess student learning outcomes in PBL team-based courses (Jorgensen and Howard, 2005b). The goal of portfolio assessment is to appropriately assess students' individual contributions to team efforts and verify that students have achieved stated learning outcomes. While using portfolios to assess student work in PBL courses has become standard practice at CQU, portfolio assessment is difficult (Jorgensen and Senini, 2005).

At CQU, students are required to submit a portfolio of their work in some courses such as Capstone Thermofluid Engineering that demonstrates the achievement of required learning outcomes as well as the degree to which each learning outcome was achieved. Students are also required to complete examination based courses such as Statics and Dynamics. In portfolio based courses, students are invited to include a subset of the following as part of their portfolio: technical workbooks, design journals, project reports, audio visual presentations, skills audit tests, peer evaluations and reflective journals (Jorgensen and Senini, 2005). Students are then required to self-assess the degree to which they have met each required learning outcome. Students nominate a grade for the course based on published criteria. Students then come to a final interview where they are expected to defend their grade with the evidence presented in their portfolios.

Background

CQU has adopted Seven Principles for Good Learning and Teaching (Table 1) based on Chickering and Gamson's (1987) review of 50 years of research on good teaching practice in undergraduate education. CQU encourages all academic staff to adopt these approaches to improve the learning journey of each student. According to the CQU website (CQU 2013a), potential benefits of implementing these approaches may include:

> *Engagement with students by creating an environment of co-operation and collaboration, thereby enhancing the learning relationship*
>
> *Focuses all stakeholders on the learning journey and puts the student at the centre Illustrates*
>
> *respect for differences and ensures the student is informed about their progress*
>
> *If utilised correctly, maximises the value of the learning experience, subsequently becoming a showcase of best practice in learning and teaching, as it is used as an authentic and holistic approach to learning and teaching.*

The university also provides a handbook of readings to support the work of Chickering & Gamson (1987) as well as advice on how to use the Learning Management System to support each of the principles.

Through discussion with a few Learning and Teaching (L&T) experts and also reading quality teaching and reflection books, I formulated a few outstanding L&T practices. Some of my excellent L&T practices are quick detailed feedback on assignments, quick and continuous engagement with

students through e-mails, telephone calls, Moodle forums, interactive- classroom discussion, reflection on and the continuous improvement of my practices, etc. I introduced innovative practices in my Solid Mechanics and Computational Analysis (ENEM14012) course from 2011 to address identified shortfalls in meeting the student evaluation targets and improving students' learning outcomes. My student cohort consists of school leavers, mature age students and students from diverse cultural backgrounds in distance and multi-campus modes. As discipline leader of Mechanical Engineering, I developed a creative 4-point strategy using my innovative teaching practices to make 'red' courses 'green' and 'good' courses 'excellent'. I work closely with discipline colleagues and program committee members to promote this strategy to enhance the learning environment throughout the School of Engineering & Technology. My KPI data was benchmarked within CQU to verify its effectiveness. Although the students' attrition rates were low, student satisfaction and response rates were initially very low (2.0/5.0 and 26%) in 2010; but, through the introduction of innovative L&T practices under my 4-point strategy, these soon exceeded the corporate targets in 2013 (4.1/5.0 and 67%) and have remained around this level in subsequent years. This improvement is significant and it is indicative of a healthy and sustainable learning environment where students learn and apply skills and knowledge in solving problems in context. The outstanding 4-point L&T strategy not only fosters a better learning journey for students, but also stimulates their curiosity and independence in learning.

Table 1: CQU's Seven Principles for Good Learning and Teaching

	Key aspects
a)	Encourage contact
b)	Develop cooperation
c)	Encourage active learning
d)	Provide prompt feedback
e)	Emphasise time-on-task
f)	Communicate high expectations
g)	Respect diversity

Table 2: 4-point strategy

Red courses to green courses	Good courses to excellent courses
Regular communication: to build strong relationships through regular e-mails, phone calls, Blackboard Collaborate, etc. **Simple/consistent Moodle site**: site should be easy to navigate, coordinator's smiling photo with brief message about you to students. All assignments should be in the same place, its format and outlook should be good. **Feedback**: should be within two weeks - the sooner the better. **Contextual feedback**: very good detailed feedback with contextual marks such as ticks, underlines, circles, etc.	**Enthusiasm:** showing care about students. **Knowledgeable to core things**: putting examples of technical issues, answering questions accurately, etc. **Regular quick communication**: instantaneously or within two hours. **Go over and above**: doing things exceeding students' expectations.

Course History

This paper describes gains in learning effectiveness from three different courses taught since 2007. The courses are Statics and Dynamics (ENEM12007), Solid Mechanics and Computational Analysis (ENEM14012), and the PBL Capstone Thermofluid Engineering (ENEM14014). All of these courses are offered in three different modes: 1) face to face (F2F), 2) Integrated System-wide Learning (ISL) and 3) Distance Education (DE). F2F students are on campus, ISL students are students that can attend lectures in real time on another campus via videoconferencing, and DE students access course materials asynchronously. The Moodle Learning management system (LMS) is used to promote the delivery of lectures and tutorials. The lectures are recorded and posted into the Moodle site of the courses on a weekly basis. Sometimes Blackboard Collaborate (BC) in Moodle is used for additional support to ISL and DE students. Figure 1 summarises the number of students enrolled in the three courses in different years. The student numbers range from 14 to 47 in a course. The course ENEM14012 was developed and delivered from 2008. The course ENEM14014 was only taught by me for five years; from 2012, another lecturer at this university has delivered that course.

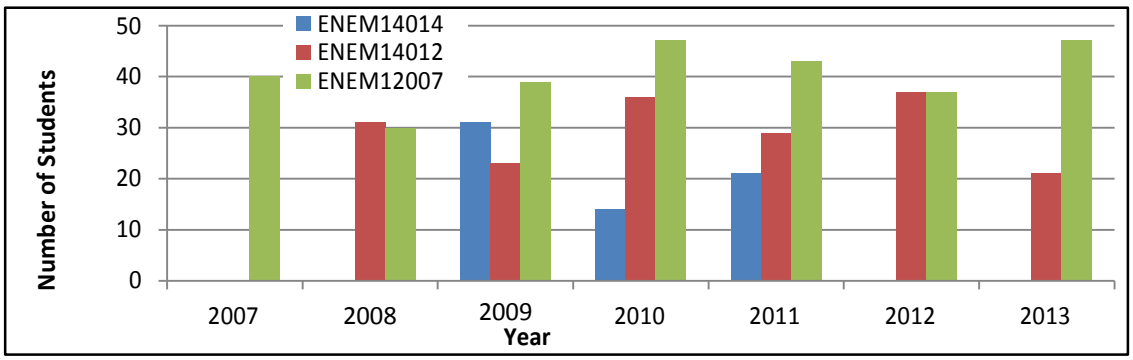

Figure 1: Number of students in each of the three courses (ENEM14014, ENEM14012 and ENEM12007)

Purpose of Changing Practice

CQU has a corporate target for student satisfaction of an average rating of 4.0 on a 5 point scale. In addition, CQU has a corporate target of at least 50% of students providing feedback in any single semester. Lastly, CQU has an attrition target of less than 30% of students not passing a course. The purpose of the changes in teaching practice over the past five years is to meet and exceed the CQU corporate targets. The metrics of the approach are threefold: 1) to improve student learning, 2) to increase student satisfaction in their learning journey, and 3) to reduce student attrition. The primary outcome is that students are prepared to apply the concepts of the courses in real life applications. The changes in practice also endeavor to increase students' feedback rate to ensure that satisfaction data is more credible. The following section summarises the different strategies used to meet these corporate targets.

Teaching Interventions

Table 3 summarises the timing of the implementation of various teaching interventions responding to student feedback over the past five years, as well as noting which of the 7 Principles of Good Teaching were used to develop the particular teaching intervention. Rather than addressing student feedback, several innovative teaching practices are employed in teaching methods to achieve the goals stated above.

Table 3 Teaching Intervention Summary (2007-2012)

Year	**Student Feedback (Course)**	**Intervention Response and which of 7 Principles from Table 1 were Applied**
2008	Instructor's handwriting is small on the board. (ENEM12007)	Instructor worked on using bigger fonts in PowerPoint slides and on writing more clearly at the board. (a, b)
2008	Students requested tutorial questions and solutions be available via PowerPoint format (ENEM12007)	Instructor provided solutions of tutorial questions in PowerPoint format (c, f)
2010	Too much content (ENEM12007)	Under active consideration to split course (c)
2011	Recordings of lectures	Happening (d, e)
2012	Open book of ENEM12007	Discussed and decision taken to have open book exam of ENEM12007 (e, g)
2012	Working on the white board on tutorial problems of ENEM14012	It is happening from year and students contribute in solutions steps (c, e)

I incorporated the feedback given by the students as reflective practices to improve my quality of learning and teaching. The strategy I followed is given below:

- Unsolicited feedback from the students was analysed in the middle of the term and incorporated into teaching methods
- Taking feedback again at the end of the term to monitor the improvement

Because of the feedback of students, I changed the handwritten notes on the white board from smaller to bigger fonts, started talking to the students slowly and shifting my tutorial delivery from hand writing on the white board to PowerPoint presentation mode. From their fortnightly reflective journals, I obtained feedback (unsolicited) at the end of the term of Capstone Thermofluid Engineering (ENEM14014) from the students. Some of the feedback was:

- *enjoying the lectures*
- *having fun in the tute time*
- *getting satisfaction*
- *the best Capstone course at the faculty*

In Term 1, 2011, feedback from a student of ENEM12007 was about not uploading the lecture notes on time for the first few weeks. It was uploaded when the resources were obtained from the guest lecturer. This was the first negative feedback and, reflecting on it for term 2, 2011, I uploaded all old resources/modified resources up to week 12 in the Moodle course website and maintained this strategy.

In a program reference committee (PRC) meeting on the 19th July, 2011 with industry representatives from local employers such as Ergon Energy, Cardno, QR National, etc, they observed that our "graduates have less understanding of the free body diagram (FBD) concept". I focussed on FBD in subsequent lectures on ENEM14012. The plan was to incorporate more resources on FBD into the lectures and the Moodle site for ENEM14012 and ENEM12007 to make this concept clearer.

The delivery of these three courses includes maintaining the course web site (Moodle site) lecture notes, tutorial questions and solutions, record of lectures, discussion forum, and online submission facility. Other than this conventional nature of course delivery, the innovative approaches of tag questions, models relating to lecture contents, linking the content to the context and animations relating to contents are stated below.

I reflected on my teaching mode and engaged students through small groups in tutorial classes to solve problems. I began to put more resources into the course Moodle site, including practice exam questions and past year questions with their solutions, an equation sheet for the exam and more problems to solve in lectures.

Tag questions

Each week I introduce two or more critical thinking concepts in relation to the current content of the weekly resources, and request students to explore these further and put them into the reflective journal of PBL courses and workbooks of other courses. The impact of this initiative is that the students are expanding the concepts with good writing and proper illustrations in their fortnightly journals and workbooks. It advances students' research skills, problem solving skills and provides inspiration for learning.

Models relating to lecture contents

In 2009, I presented an endpost of a glued insulated rail joint to the material selection lecture of second year mechanical engineering students. I explained the type of material of the endpost and why the material was selected. Later, by reading the reflective journals of that week, I realised the importance of showing models in the lectures. I then decided to prepare many models relating to course materials. The impact of this is that the students can understand clearly the plane (area) where a force is acting, whether it is acting perpendicular to or in the plane for example. The models make their learning easier and create motivation and inspiration for learning.

Linking the content to the context

I select final year thesis projects and different projects in PBL courses that are related to real life problems. The students are interested in these types of practical problems. In the Capstone Thermofluid Engineering course (ENEM14014), I select building energy management projects relating to CQUni Rockhampton buildings. They use DesignBuilder and EnergyPlus software to do the drawing and simulations, resulting in good outcomes.

Animations relating to contents

Animations, videos, etc are very effective for students' learning. I now include animations in lecture notes to discuss the difference between a rigid body motion and deformed body motion, for example.

Class tests in PBL courses

In terms of better assessment of PBL teaching folios, I utilised two class tests in my ENEM14014 course. In other PBL courses at our University, the lecturers are introducing the concept of class tests.

Results and Discussions

Achievement and quality of learning and teaching is very important for a lecturer in developing his/her career. Grade distributions are a good indicator of the overall quality of course development, delivery mode and style of delivery, communication with the students, giving feedback on time etc. Figures 2-4 illustrate the grade distribution (including failure rate) of three courses I taught in the years from 2007-2011. Initially the attrition rate for Statics and Dynamics (ENEM12007) was increasing gradually (Figure 2). This is the students' first conceptual course in their discipline. As the innovative teaching methods were introduced, the attrition rate dropped to a satisfactory and sustainable level, and the percentage of HDs was increasing (Figure 1). Similar types of approach helped to achieve good student attrition rates in other courses (Figures 3-4). On an overall basis, the grade distributions show the positive impact of my teaching methods, course materials developed etc. as the failure rates are significantly below the university average of 30%. Failure rates of up to 60% are recorded in Engineering Mechanics courses at the University of Wolongong (Goldfinch, 2014).

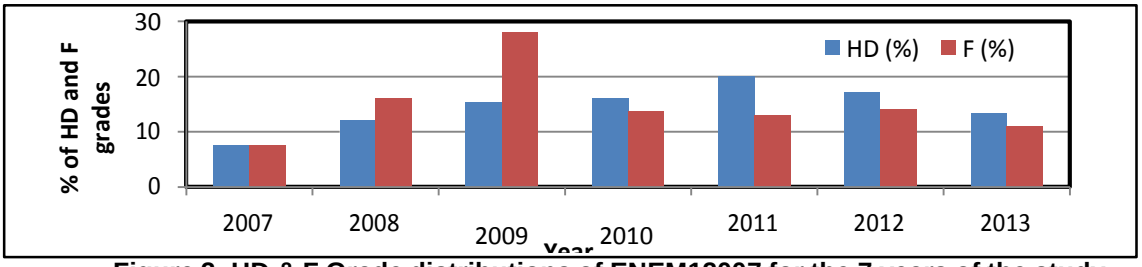

Figure 2: HD & F Grade distributions of ENEM12007 for the 7 years of the study

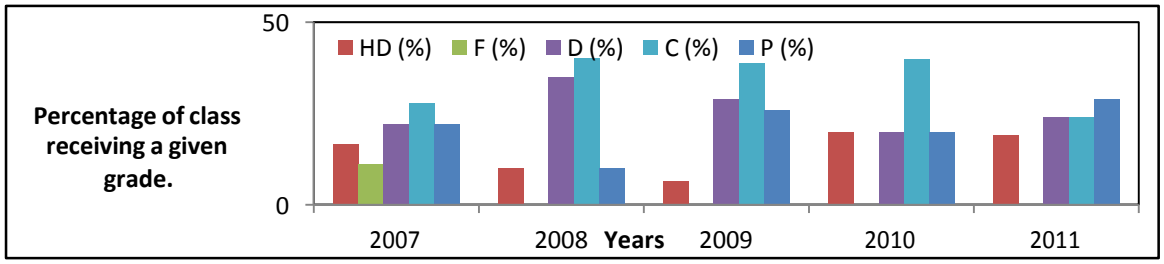

Figure 3: Grade distribution of ENEM14014

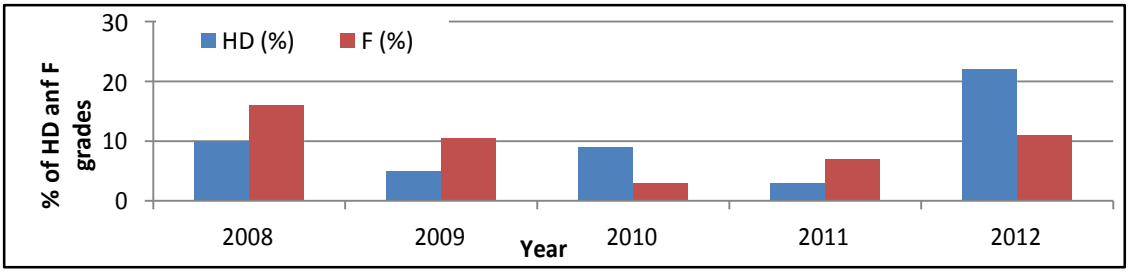

Figure 4: Grade distribution of ENEM14012 over the past five years

Instructor Observations

The author observes from solicited and unsolicited student feedback that they enjoy the style of teaching method of introducing physical models, animations and other similar concepts relating to the contents of the lectures and tutorials. This is reflected in student grades (Figures 2-4) and satisfaction (Figure 5). While visiting students during their tutorial sessions, I have observed that they can work independently and can develop correct equations to be used in engineering solutions. Most of the time, the answers they are getting are correct.
This is an example of the impact of my innovative teaching and learning processes.

Student Satisfaction and Feedback

The corporate requirements for a competent teacher at CQUniversity are to achieve student satisfaction of 4.0 out of 5.0 and 50% student feedback rate. Figures 5-6 show student satisfaction and feedback rates respectively for different courses in different years (a tabular form (Table 4) presentation is for ENEM14012). They suggest that some changes to teaching practices are needed in some courses to enhance student satisfaction and feedback rates and to improve the student learning journey. It is expected that, after graduation, students can go into the workforce and start working with little or no assistance. For ENEM14014, student satisfaction was improving beyond the university target.
ENEM14012 shows a similar trend; it started with low satisfaction when it was first developed and delivered, but reached the target. For ENEM12007, it was noticed that it was hard to achieve the target level of student satisfaction, most likely because it is the first conceptual discipline subject for students. It went to a low level below 3.0 and then improved linearly. The teaching methods changed in 2011 with the inclusion of a guest lecturer. This created problems in communication with students and properly maintaining the Moodle course site. On the other hand, the initial feedback rate of all courses (Figure 6) was low, but has recently been improving significantly. Before term 1, 2012, the importance of feedback rate was not properly recognised nor adequately addressed. However, higher response/feedback rates from students were evident from term 2, 2012. Some colleagues at the engineering school of CQU employed these innovative approaches; the improved performances of course delivery and students' learning are evident. By way of comparison, I benchmarked other peers' data in relation to students' satisfaction. During 2014, 12.9% in Term1 & 4.3% in Term 2 of the teaching staff had student satisfaction rates below the corporate target in the published data for areas such as overall satisfaction, learning resources, assessment tasks, requirements & feedback. This percentage of red flagged data is gradually reducing. Employing innovative practices like my '4-point' strategy in teaching is thus critically important to achieve sustained improvement in course delivery outcomes. Thus this innovative approached can be employed in engineering science courses in the universities of Australia and overseas.

Table 4: Satisfaction and response rates for ENEM14012 (n is the student number)

Year/ student number	2010, n= 34	2011,n= 30	2012, n= 37	2013, n= 20	2014, n= 28
Students' satisfaction	**2.0**/5.0	4.0/5.0	4.0/5.0	4.1/5.0	4.1/5.0
Response rate	**26**%	**25**%	65%	67%	57%

Summary

My outstanding L&T practices work nicely to stimulate students' eagerness to learn and to develop the research and analytical skills useful for their lifelong learning. The above mentioned innovative practices enable my students to create an interactive class, leading to high levels of interpersonal and presentation skills. My innovative approaches improved student satisfaction and enhanced learning outcomes for diverse undergraduate mechanical engineering cohorts in my Solid Mechanics & Computational Analysis course. Other colleagues of engineering disciplines employed these and overall improvements in course delivery and students' learning are noticed in recent terms at our school. It is trusted that, if the adopted approaches in L&T work fine at CQU, they can equally be good for engineering and science disciplines at different universities in Australia and overseas.

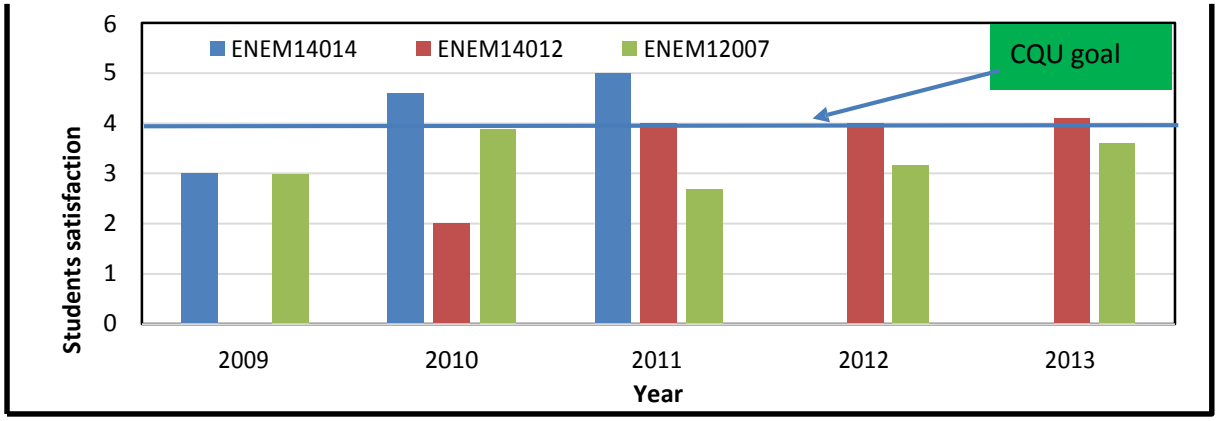

Figure 5: Student satisfaction ratings for the past 5 years in the three courses of interest (corporate goal for student satisfaction rate of 4.0 is indicated on the graph)

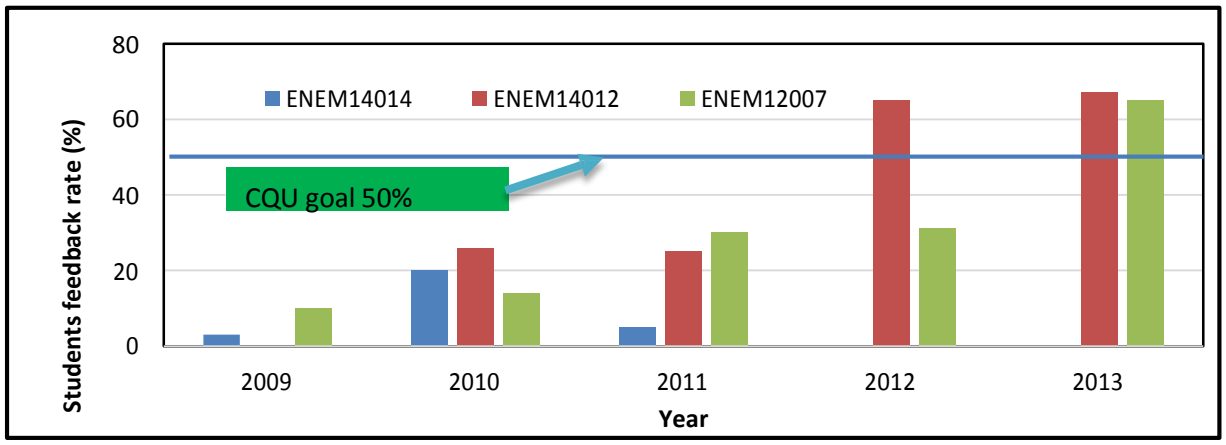

Figure 6: Student feedback rates in the three classes for the last 7 years (corporate goal of 50% return rate is indicated on the graph)

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