Student performance in an online postgraduate course on fibre composites for civil engineers

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***Abstract**: This paper presents an evaluation on the performance of students from 2008-2011 in the Australia's first online course on fibre composites for civil engineers. The evaluation focused on the overall performance of the students to determine the effectiveness of the course content and delivery. In its 4 years of delivery, the course gained significant popularity as seen by the increased in the number of enrolled students coming from different demographics. The introduction of innovative learning resources resulted in the increasing level of interest on the different study modules. There is also a high satisfaction of the students to the course as shown by their active participation, quality of overall performance and feedback. It was found out that postgraduate and senior undergraduate students performed better than students who have not taken the fundamentals of engineering design. Based on the results of this study, improvements are planned to further enhance the course delivery and to ensure a more effective student's learning.*

Introduction

One of the main reasons for the continued lack of penetration and growth of fibre composites in the construction industry is that civil engineers have not possessed the information and design tools to truly exploit the advantages of these materials. Mirmiran et al (2003) indicated that civil engineering graduates are not sufficiently trained to design and specify fibre composite materials for construction. While several international and national conferences, workshops and symposia are being held to disseminate information on the recent advances in materials, manufacturing techniques and design of fibre composite materials, these information are contained mostly to academic and researchers working in universities and research institutions, and not to practicing engineers. Taly (1998) suggested that teaching composites design and application can effectively disseminate the knowledge on composite materials in the civil engineering community. In both the APFIS 2009 Conference in Korea and the CICE 2010 in China, the importance of education in the area of fibre composite for civil infrastructure was highlighted.

Many institutions and foundations are now taking the initiative to translate the gathered knowledge on fibre composites into teaching curricula and the classrooms. The National Science and Foundation in the US has sponsored a number of integrated research and educational programs focusing on developing undergraduate and graduate courses on FRP composites in civil engineering (Davalos and Quiao, 2001). The working group on Education of the International Institute for FRP in Construction and the ISIS Canada Education Committee are now developing education modules on FRP composites in construction. The Composite Construction Laboratory in Switzerland has introduced a course on advanced composites in engineering structures for postgraduate on-campus students. Though there have been advanced courses on fibre composites offered in some universities, all of them are delivered through face-to-face delivery. The technical nature of the topic and the lack of a University-accredited program in Australia on fibre composites have lead to the difficulty of incorporating a new course in a civil engineering program. Web-based delivery can provide the best possible learning opportunities on these advanced materials in a more flexible environment.

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In 2008, the first web-based postgraduate course in Australia on fibre composites for civil engineers making use of the technical expertise of staff at the University of Southern Queensland (USQ) and the pioneering research and development work at the Centre of Excellence in Engineered Fibre Composites. While online-based course delivery has become an attractive option for expanding its reach to new students and to facilitate the scheduling of existing students, Orabi (2004) found that it takes much more time to teach and administer online courses. Allen and Seaman (2006) also mentioned that students need more discipline to succeed in online courses. Thus, it is imperative that the effectiveness of a new online course be determined through an evaluation of the performance of the students. In this paper, an evaluation of the student's performance in ENG8803 – Mechanics and Technology of Fibre Composites was conducted. Similarly, the student's perception of the course with respect to content and delivery were evaluated. The result of this study will be useful to determine the effectiveness of the current course delivery and identify opportunity for the further improvement.

Course Design

The online postgraduate course on fibre composites is designed as a postgraduate program or for continuing professional development for civil and structural engineers who have had minimal or no exposure to fibre composites in their training curriculum. Another is to make this an elective course for undergraduate engineering students in their last year in the university.

Course content and delivery

The course on ENG8803 aims to address the need for the improved understanding of composite materials and their behaviour within the civil engineering context. This course is intended for practicing civil and structural engineers who need to acquaint themselves in the principles, recent design techniques and the latest utilization of the fibre composite materials in the civil infrastructure. Starting in 2009, this course was also offered as an elective course for undergraduate engineering students, who are in their last year in the university. Table 1 lists the study modules for ENG8803.

Table 1 Course content of ENG8803.

Module	Topics
1	The application of composite materials in civil engineering structures
2	Polymer matrix materials for civil and structural engineers
3	Fibre reinforcement for composite materials
4	Composite material behaviour
5	Structural design of fibre composites in civil engineering environment
6	Lamina design properties
7	Flexural behaviour and robustness
8	Determination of characteristic lamina properties by physical testing
9	Durability of fibre composites

Course delivery

Face to face delivery may not be feasible and sustainability of the course can become a problem for postgraduate students and professionals. With USQ being recognised as Australia's leading e-learning provider for online and distance education, web-based delivery is carefully considered to provide the convenience and flexibility for students to complete the course at their own pace at a time and place that fits in with their other commitments as the target student cohorts are already employed in some capacity. Thus, the course is entirely web-based using the Moodle system with the study materials regularly uploaded through the course homepage on the StudyDesk.

Assessment

Table 2 summarizes the assessment criteria for ENG8803. In 2008, the assessment only includes 2 major assignments: Assignment 1 which covers modules 1-4 and Assignment 2 which covers modules 5-9. In every assignment, each student is given a different set of design parameters to avoid any collusion and uniqueness of the answer. Submission assignments were a compulsory requirement for

the subject assessment. From 2009, online quizzes and discussion are introduced and included in the assessment criteria. The quality of participation, questions and comments are graded for the on-line discussion.

Table 2 Assessment criteria and weighting.

Criteria	2008	2009-2011
Assignment 1	40	30
Assignment 2	60	50
On-line Quizzes/Discussion	0	20 (10/10)
Total	100	100

E-learning resources

Several innovative teaching techniques are implemented and a number of developed resources are made available in the StudyDesk to enhance student's learning. These innovative teaching methods and new learning resources are developed to increase course attractiveness and produce better educational outcomes. The key resources that are used in ENG8803 are online discussion and quizzes, online lectures, video of testing and manufacturing processes, electronic submission and marking. The detailed description and the effectiveness of a variety of learning resource and assessment tools developed for this online course was published by Aravinthan (2010) in another paper.

Data collection and analysis

The performance of students for 4 years (2008-2011) of course delivery was evaluated. This is conducted by examining the number of access/views made by the students on the different activities in each study module throughout the semester. The responses of the students in the initial and final survey were also analysed. An evaluation of the overall performance of the students is also conducted.

Course outcome and student's performance

The ENG8803 has gained considerable interest to both postgraduate and undergraduate students since the course was offered in 2008. This section presents the student's performance in the last 4 years to determine the effectiveness of the delivery and content of the course

Number and demography of students

An initial survey at the beginning of semester was conducted to get a better understanding of the student's expectations in the course. The survey includes the program that the students are taking, location, organization, and familiarity with composites. A summary of this survey is listed in Table 2.

Table 3 Location and level of studies for ENG8803 students.

State	2008	2009	2010	2011
New South Wales	1	2	4	4
Queensland	3	7	7	14
Tasmania	0	1	0	0
Victoria	0	2	1	1
South Australia	1	1	1	1
Western Australia	1	1	0	2
Overseas	0	1	2	1
Postgraduate	7	10	11	5
Undergraduate	0	5	4	18
Total	7	15	15	23

The results show that there is a significant increase in the number of students who enrolled in the course from 2008 to 2011. From only 7 students who took the course in 2008, this number increased to 15 in 2009, 15 in 2010, and 23 students in 2011. The flexibility of teaching delivery also resulted to at least one student enrolled from each state in Australia in 2009. From 2009, at least one student from

overseas has taken the course showing the increasing level of interest in the course not only from students studying in Australia but also by international students. As the course is delivered online, it is very attractive to many of the student's works part-time. The results of the survey show that most of the students who took the course are working in the construction and consulting industries with more than half of them have poor knowledge in fibre composites. The course also gained popularity in recent years for undergraduate engineering students as their elective course. It is notable that a total of 18 undergraduate students enrolled in 2011. This is partly attributed to the increased in awareness of the students in fibre composite material and its potential it civil infrastructure through their exposure to this material in the booth activity on *Fibre Composites – process and application* during the Professional Practice at USQ wherein an overview on fibre composites is presented and a visit to a number of fibre composites manufacturing facilities within Toowoomba is arranged for the students.

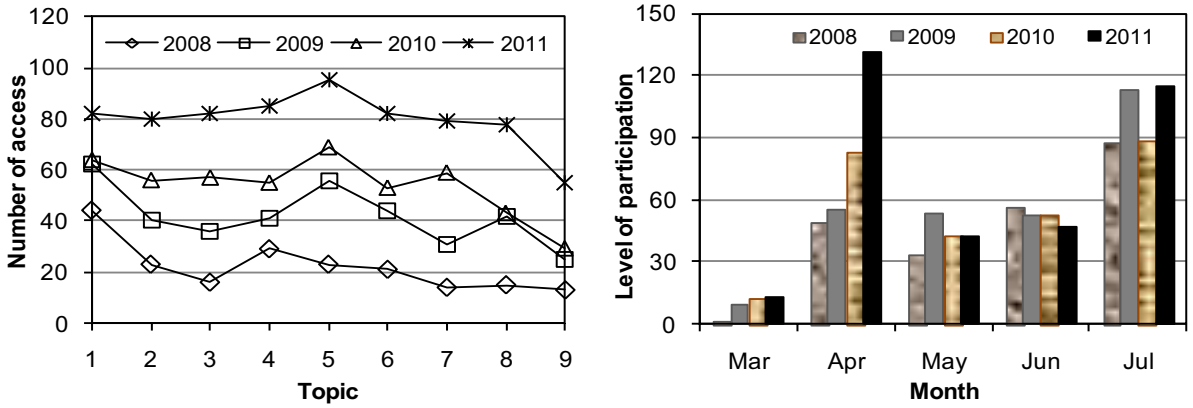
Student's motivation

The main reason the students are citing for taking the course is for them to have a better understanding on fibre composites and to effectively use this material in real world situations. Most of the students have also indicated that they want to develop their skills to such a point where they can provide sound input on the design of structural components using fibre composites through understanding of the design methods and considerations for this advanced material. Furthermore, students have taken the course to broaden their knowledge on the structural application, manufacturing processes, and how fibre composites can provide solution in a number of civil engineering problems. One mature student, who is working as a bridge engineer, mentioned that "*I took this course as fibre composite was not part of the syllabus at the university where I completed my civil engineering studies. I am also interested in gaining insights into fibre composites and its applications in the bridge industry*."

Student participation

Figure 1 shows a normalized value of the level of participation of students (total number of participation per student) during the semester and the number of times the students have accessed each study module. In Figure 1a, the level of participation includes the number the students who have accessed the different study modules and other learning resources, attempted the quizzes and posted in the discussion forum. The figure indicated that the students accessed the StudyDesk the least in March as the students are just starting to familiarize themselves with the StudyDesk and the course. As the semester progresses, the students have accessed the StudyDesk and studied the course modules more often. In 2008, the students accessed the StudyDesk the most during the months of June and July. It is important to note that Assignments 1 and 2, which are the only basis for assessment, are due on these months. In 2009, the level of participation is at its most in July when Assignment 2 is due while in 2010 and 2011, the students have accessed the StudyDesk more frequently in the months of April and July where the major assignments are due for submission. Interestingly, the level of participation remains high for the months of May and June. This is due to the introduction of the quizzes, online discussions, guest lecture, and online videos which keeps the level of interest on the course.

Figure 1b shows that the most read topic is the one related to the design of structures from these advanced materials (Topic 5). There is also a high level of interest in the understanding the behaviour of fibre composite materials and review on its developments and application in civil infrastructure. This is compatible with the result of the initial survey on the interest of students taking the course. It can also be noticed that in the latter years of offering, the students tend to realize the equal importance of each study module as indicated by almost the same level of interest for each study modules except for the topic on durability which seems the least perceived topic by the students. The increased interest in most of the study modules can be attributed to the introduction of online discussion topics and quizzes related to these modules wherein students need to demonstrate their knowledge and understanding. Since these learning resources are introduced, most of the students have actively participated in the online discussion forum and tried answering the online quizzes. Some of the students have tried answering the online quizzes more than once even though only the first attempt on the online quizzes is being marked. Each student also viewed the all the guest lectures and online videos at least once during the course. In general, the increase in the number of students taking the course results in the increase in the number of students accessing the different study modules.



(a) Level of participation **(b) Access per study topic**

Figure 1: Participation of students

Overall performance

Another way to consider the performance of students in the course is to evaluate their overall marks. While the final course grade appears to be a function of a combination of objective and subjective measures of student performance, Daymont and Blau (2008) suggested that the overall class performance is a good indication of the satisfaction of students with the course delivery as well the greater perceived student learning. Figure 2 shows the distribution of student's marks for ENG8803 from year 2008 to 2011. From 2008 until 2010, a normal distribution curve is noticed for the calculated marks with most of the students getting satisfactory grades of either A or B. However, the high number of undergraduate students who enrolled in 2011 resulted in more students with only a passing grade C. This also resulted in the first student to get a failing grade. The better class performance in years where the majority of the students are composed of postgraduate and senior undergraduate students can be due to the fact that these students are more self-motivated and self-disciplined to find the course content satisfactory. Furthermore, these students are better equipped with technical knowledge that is pre-requisites to the course. In contrast, the students who have no prior technical knowledge in analysis and design of materials had difficulty in understanding even the basic concepts of composite materials as reflected in the quality of their submitted assignments.

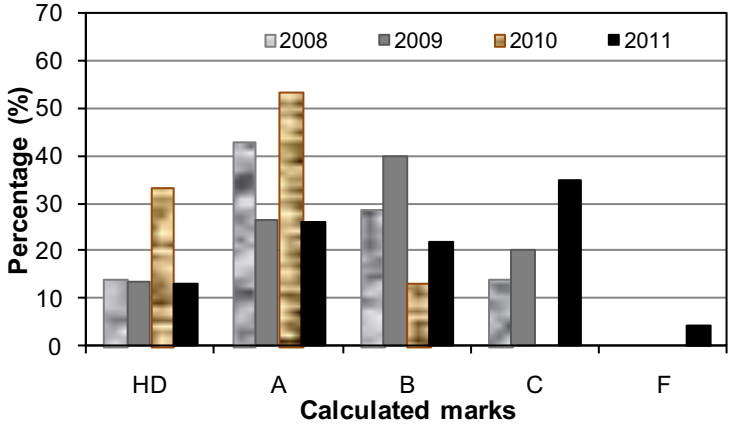


Figure 2: Calculated results summary

Student's feedback

At the end of the semester, the students are asked to complete the survey designed to assess their satisfaction of the teaching team, learning materials and the course with respect to content and delivery. Most of the students are consensus that they learned a lot from the course and all the module learning is very good. The students also agreed strongly that the course content was structured to effectively hep them to learn. They are very satisfied on how prompt the teaching team are responding to their queries and giving them assistance which maintain their level interest and participation in the course. The feedbacks have also been helpful in their learning. Below are the selected comments by the students on how they perceive the content and delivery of the course with respect to their learning:

- *"The online resources in the course are very useful learning materials. I have gained a lot of knowledge on fibre composite materials from my previous almost zero knowledge."*
- *"This is an excellent course, very relevant. I enjoyed learning and participating in the course. I can see this course becoming very popular in the future, especially on students who are more focused on structural design."*
- *"Some worked examples would make own learning materials more complete."*

Future changes

This paper adds to our knowledge on the performance of students in a newly introduced engineering web-based course on fibre composites, which was introduced in Australia for the first time in 2008.The course has begun to be embraced by more undergraduate students who have special interest on advanced materials in civil infrastructure although the course is designed for the practicing engineers. The evaluation of student's performance showed that postgraduate and senior engineering students performed better than the more junior undergraduate students; thus, it is recommended that completion of the design and analysis courses as a pre-requisite to the course be mandatory. This may result in a slight decrease in the number of enrolments but will ensure that students will be more successful in their learning. The weighting of the online discussion is also increased to 15% in the next course offering with the Assignment 1 reduced to 25%. This approach is anticipated to result in a more active discussion and participation throughout the semester. Discussion topic and online quiz related to durability will also be introduced in order to increase the awareness and interest of students in this topic. Students need to realise that durability is an important issue as it affects the service life and maintenance consideration of structures even though it does not directly affect the structural design.

Conclusion

This paper evaluated on how the students performed in an online course on fibre composites, ENG8803 from year 2008 to 2011. In its 4 years of delivery, there has been a significant increased in the number of students taking up the course from different demographics. The introduction of online discussion and quizzes has resulted in maintaining the level of participation of the students throughout the semester. The results of the evaluation points toward the satisfaction of the students to the course as shown by their active participation, quality of overall performance and feedbacks. However, it was found out that postgraduate and senior undergraduate students performed better than students who have not taken the structural analysis and design subjects. Overall, the student's performance indicated that the course provided an opportunity for learning. Based on the results of evaluation, improvements are planned to further enhance the course delivery and to ensure a more effective student's learning.

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