OER07242

Piloting Online Learning in Engineering Education

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Refereed Paper presented at AARE, Nov 2007, Fremantle

Abstract
This paper reports the findings of a pilot study introducing online learning in a school of engineering at a major Australian university. We are in the process of developing online courses, using blended learning. Blended learning denotes the blend of face-to-face with web-supported learning, and promises to offer globally disparate students educational access. In the pilot project we developed two online lectures and embedded these into the University's LMS, followed by a face-to-face workshop, covering a fundamental course concept. As part of the process we included a short assessment to allow students to check their understanding of the topic. A final test of their comprehension was included as part of the course exam.

The purpose of the study was both to help our undergraduate engineering students learn a fundamental engineering concept, and gain a greater understanding of how students learn in an online environment. We were interested to evaluate, on a small scale, the ways in which we are developing our course materials and be able to gauge firsthand the impact on students' learning. Blended learning offers opportunities for deep and persistent learning when well designed and developed, but also raises some questions. These are further explored in the paper.

Introduction
There is a view that the internet provides an almost limitless arena for knowledge, and that the development for the twenty-first century is a "brave new era of borderless learning" (Brown, 2000, p. 348) through the provision of online learning and the establishment of e-Universities. Although it is now some years on from when that view was expressed, the School of Mechanical Engineering at the University of Western Australia, is participating in a large research and teaching project to develop a Master of Engineering to be delivered via a blend of learning modalities, combinations of face-to-face, printed materials, and technology-based or online learning. This paper reports the findings of a small pilot study, undertaken as part of the larger project, as we introduced our second year engineering students to the concepts of online learning and then evaluated the results in order to better understand how students accessed online learning.

For the pilot study we developed two online lectures and embedded these into the University's Learning Management System (LMS), followed by a face-to-face workshop, covering a fundamental course concept. As part of the process we included a short assessment to allow students to check their understanding of the topic. A final test of their comprehension was included as part of the course exam. The results from the exam were then compared with the previous year's results for a similar exam question. This paper presents the findings and our ongoing evaluation of the process and how we will use the

information gathered to feed back into our larger project with the aim of improving our understanding and our delivery.

Background

The following section of our paper gives a brief discussion of blended learning before moving on to describe how we utilised this form of learning within our pilot and what the outcomes were. The Master of Engineering (Energy Systems Management) is being designed using a blended learning format to enable students, who are unable to participate in traditional classroom-based learning, to further their education, no matter where they are physically located. Our students are global people working in the oil and gas industry, where they are more often away from home, then near the bricks and mortar of university buildings, which would otherwise enable them to participate in life long learning opportunities. In late 2005 the then Head of School came up with a plan to offer a blended learning Masters course to mobile and distant employees of the oil and gas industry. There was seen to be a need for courses of this type, particular in an era where more and more students search globally for education that suits their particular needs, lifestyle demands and learning styles. Therefore, to ensure that the course would work in the way that we are anticipating, we decided to run a small pilot project.

The aim of our pilot project was to test the blended learning delivery in a short, controlled environment. Blended learning, a term used to denote the blend of face-to-face with web-supported learning, is promising to offer student improved educational access throughout the world. The promise of blended learning is to bring "high touch" education to students globally situated, drawing on the strengths of both face-to-face as well as the flexibility of online learning (Graham, 2006). It seeks to do this via a blend of learning modalities, utilising such technologies as learning management systems, video conferencing, mobile devices as well as the more traditional face-to-face delivery. It not only provides for these extended modalities, but has also been successfully trialled with a number of different educational learning styles, including individual, paired and collaborative group work, through the use of chat, discussion groups, and mobile devices (see Bonk & Graham, 2006b). It offers opportunities for deep and persistent learning when well designed and developed. Whilst blended learning offers these exciting opportunities, we have found that it also raises some questions, and these we return to briefly at the end of the paper.

The blended learning format allows us to draw on the strengths in the established fields of distance and electronic learning (e-learning), where distance learning is distinguished from conventional face-to-face provision of education for students who cannot physically attend a campus, and delivers materials through the medium of the post office. E-learning encompasses the online provision of the same course materials, including amongst other things recorded lectures, course readings and assessments through, for example, a learning management system. The strengths of these modalities of learning are the availability of learning opportunities to students wherever they are situated, at a time and place convenient to them (Graham, 2006). Yet, the literature on technology-assisted learning identifies a number of issues that we would like to briefly rehearse here before moving on to a description of our pilot project, within the framework of the broader

activities of our team, and a discussion of how we faced some of these challenges in the process of creating a quality learning opportunity.

Some of the inherent weaknesses in e-learning and distance learning include the often poor design (especially of many e-learning courses, which are often just an online version of a face-to-face course), the relative isolation of many of the students and their lack of immediate interaction with teachers/lecturer and other students, and the assumption of autonomy of the student and the attendant responsibility for taking the initiative and self-discipline to listen to lectures, engage with the course materials and complete the set assignments (Oh, 2003). One of the most commonly cited issues is the apparent practice of placing existing face-to-face units on the web and calling them e-learning, yet they are more often a reading experience rather than a learning experience (Blass & Davis, 2003). A major criticism has been the lack of engagement students have or are encouraged to have with the materials (Oh, 2003). A fundamental construct of learning is the development of an interactive learning environment that will engage students in their learning. There has been a growing interest in the development of Vygotsky's constructivist principals of teaching and learning, especially in online education (Altalib, 2002). In order to achieve the desired learning outcomes, students must actively engage with the subject, its content and each other, as well as a interact with a learning facilitator. From a constructivist perspective students are required to construct their own meanings in an environment that is principally student-centred and encourages flexibility, accessibility and an understanding of the different learning styles of the students. It has therefore been imperative that the instructional designers in our project "help create environments for learning, which in part are populated with predetermined learning resources, yet contain within them tasks, activities and spaces with the potential to bring forth new types of learning interactions, learning resources and outcomes not pre-ordained by traditional instructional design approaches" (Segrave & Holt, 2003, p. 10).

In order to produce a quality online learning experience, Blass and Davis (2003) suggest a number of criteria that should be met. These include ensuring that the online learning experience is both appropriate to the subject and sustainable over time, constructing the material to achieve the learning objectives stated, and building it around pedagogy rather than just the functionality of the technology, creating appropriate spaces for both student-student interactions and for student-faculty interactions, and finally ensuring that both the student learning and the online learning product are effectively assessed. Oh (2003) lists similar criteria for effective online course construction but adds that the whole learning environment must match the learner needs. He makes the point that an important player in e-learning is the student, and that part of the focus of the construction of the learning material must be on their learning needs and demands.

Therefore, what we are trying to develop in our Masters course is a balance that recognises that our potential students are working people in an industry with great mobility, complexity and variety. It is also an industry that has seen tremendous technological development in its relatively short history, and hence many of our current and potential lecturers are in fact industry experts working in the field. It is to this end that we included in our definition of blended learning the concept of m-learning or

mobile learning, recognising the lecturers' mobility as well as the nomadic nature of our student population. This mobility should be recognised as including both the real and virtual, the flow of people, images and information, that crosses societal borders "in new temporal-spatial patterns" networked across the globe (Urry, 2000, p. 186). It recognises the unpredictability, immediacy and speed of movement of people in an industry where its product, the discovery of new explorations, and viability of old fields, dominate the popular media. But it should be recognised that the mobility of students even in other areas of higher education show dramatic increases (see Shaeffer, 2006, for figures pertaining to the international mobility of students across OECD countries).

Our focus, in the pilot project, has been therefore on producing a quality product that is geared towards providing an appropriate balance between the needs of the students to learn the materials and in providing them with a successful learning experience. Yet, we did not want to get caught in the 'hype cycle', where e-learning is necessarily seen as the best, creating unrealistic assumptions of what the technology will do in the learning environment (Clegg, Hudson, & Steel, 2003). Instead in the pilot study, as we hope to do in our larger project, we sought to encourage the students to discuss the materials with others, and offered them the opportunities to rehearse the materials and engage with them in a number of different settings. Technology assisted learning for us here at the University, is seen as complementary to, not instead of, the traditional model of education. How we see this working in practice, within the broader framework of the Blended Learning Project, is described in the next section of the paper.

The Pilot Study

The aim of the pilot was to test the proposed blended learning delivery in a short, controlled environment. We wanted to see how students would access the materials provided, and whether the engagement in the different forms would encourage improved understanding for the students. It was proposed that the study be run utilising a second year engineering unit, Process Engineering. "Heating values and enthalpy" is a fundamental concept, which second year engineering students typically have great difficulty in understanding. It is an essential concept that, when not well understood, has repercussions in third and fourth year petroleum engineering. Previously, students had covered the material in three lectures and one workshop. This was then followed by a question in the end of semester exam. The comment from the third year lecturer was that it was his impression that students had failed to grasp the material in their second year, and he always had to re-teach the material in the third year. An examination of the students' exam results from previous years, confirmed this perception.

It was proposed that the lectures that covered this topic be redeveloped using a blended learning format. We re-developed the lecture materials using PowerPoint presentation with audio, and converted this to flash for web delivery using Articulate Presenter and Engage, and uploaded it on to WebCT. WebCT is the University's LMS, and all students have access, and must access it to retrieve and submit assignments and course notices. However, the material for the first lecture was condensed, there would be only one lecture, covering the entire concept, which would be presented in this manner. As part of the process we included a short electronic quiz, with questions for reflection, to allow

students to check their understanding of the concept. The student also participated in a face-to-face workshop to ensure that they covered the topic adequately and to answer any questions they may still have had. The lecture was then followed by a short assessment, to allow students to check their understanding of the topic. This was followed by a second recorded lecture, which went through the assessment and gave the students an opportunity to check their responses. This second recorded lecture was made available to the students prior to the final exam. The final test of their comprehension was included as part of the course exam. The advantage of providing the material in these multiple ways was to ensure that students had extended opportunities in an interactive setting for learning the material. We then evaluated the students' learning by comparing their results with previous year results for the exam questions on the same topic.

One of the advantages of offering the materials via the university's learning management system was the opportunity to track students' usage and compare this with the results. We created the learning module as a SCORM (Sharable Content Object Reference Model) module and this allowed us not only to track access but also the length of time accessed. This gave us some interesting results, which will be discussed below. In the year prior to the Pilot, 46 students had completed the exam. In the year of the Pilot 53 students completed the exam. To give us a better comparison we randomly selected 30 students from each group. We then gave each of the sets of exams to two new markers to ensure a fair comparison from year to year, utilising an exam marking key prepared by the lecturer. Exams had all identifying material removed from them, including students' names and where necessary the previous results recorded. We then compared the results and related these to the time students spent in accessing the online materials. Finally, we asked students in a WebCT questionnaire to briefly feedback their experiences of the Pilot study. The findings of our study are discussed in the next section of the paper.

Findings

The findings of the pilot study proved very interesting and show that students had very different access patterns but overall appeared to benefit from the online experience. As the study was small, undertaken with different groups and at different times, the findings can not be called conclusive. As well there were some technical problems, which may have affected the outcomes, and these and suggestions for where we will go from here, will be discussed at the end of the paper. We will first give an explication of who accessed the online materials and how long, and how they fared in the assessment and their exam, before moving on to give the comparisons of the two sets of exam papers.

One of the main difficulties with recording the data was that the SCORM communication between WebCT and the lecture did not function in the way anticipated. Problems arose when students used internet browsers other then Internet Explorer, or Mac PCs. The lecture was 38 minutes long, and the SCORM sequencing should have recorded whether students completed the lecture or not after viewing all the slides, how many slides they viewed, and for how long they accessed the lecture. This did not happen in quite this way and students' attempts were listed as incomplete, even though they had accessed all slides and often for times of over 2 hours. For this reason, where students have viewed all the slides and had sat through the materials for longer than 40 minutes, even though the

SCORM results listed them as incomplete, we counted them as having completed the material.

53 students enrolled in the course and sat the exam at the end of semester 2, 2006. Access by the students varied from 20 hours to not at all, although typically students accessed the material about 52 minutes. There were five students who did not at any time access the lecture or the solution to the assignment once it had been posted on WebCT. All students submitted the assessment; Table 1 shows their access to the lecture and the results for their assignments.

Assignment result (out of 25)	**< 12.5**	**12.5 to 14.5**	**15 to 17**	**17.5 to 19.5**	**≥ 20**
No access	3		1		1
Not completed	1		3	2	9
Completed viewing the lecture	1		6	10	16
Total (n=53)	5	0	10	12	26

Table 1: Student access to lecture and assignment results

All students enrolled in the course sat the exam. Of those who sat the exam:

- 24 students completely viewed the lecture
- 6 students completely viewed the solution
- 4 students completely viewed both
- 5 students did not access the lecture or the solution

All those who failed to access the lecture or solution failed the relevant question in the exam. Table 2 shows their access to the lecture and the solution and their exam results.

Exam result (out of 30)	**< 15**	**15 to 19.5**	**20 to 24.5**	**≥ 25**
No access	5			
Not completed	11	8	1	3
Completed one	7	4	10*	
Completed both		4		
Total (n=53)	23	16	11	3

* 8 completed the lecture

Table 2: Student access to lecture and solution and exam results

Year	**2005**	**2005**	**2006**	**2006**
Marker	A	B	A	B
Max	29	27	28	26
Min	0	1	1	1
Mean	16	13	21	17
STDEV	8	7	6	6
Mode	21	15	21	18
Median	17	14	22	18

Table 3: Comparison of exam results for 2005 and 2006 by different markers

Both sets of exams had been remarked by two new markers using a marking scheme prepared by the lecturer. When their marks were analysed it was obvious that one marker was more lenient than the other. However, as the results in Table 3 show, there was a consistent disparity between the two markers across the two groups of exam papers. The average final result has displayed a marked increase in 2006 irrespective of marker disparity. The mean result increase for marker A was five marks, and for marker B four marks. Thus on average, the marks of the 2006 class had improved over those of the 2005 class.

There were some interesting and surprising findings. In one instance, when completing the assignment, there was one student who did not access the lecture, yet gained a high (<20) assessment result. This same student failed to access the solution when it was posted, and subsequently failed the exam question.

The student feedback

The students were also asked to give their feedback on the presentation of the lectures. We used the WebCT questionnaire option to gather the feedback and made the completion of the feedback questionnaire optional. Of the 53 students enrolled, 33 students chose to complete the questionnaire. The comments were collated and similarities and differences were identified. Most students said they enjoyed the online experience and wished to see it utilised further. However, there had been a significant problem with the quality of the sound recording and students found it sometimes difficult to listen to and wanted to see this improved. Some students were concerned that the online materials would eventually replace all the face-to-face lectures, as one student said, “I feel that live lectures should not be replaced by online lectures and this format should be chosen only when live lectures are impossible to deliver”. Overall though the reception was good as this indicative comment illustrates, “Good use of technology as you could revisit any troublesome areas or see how values were attained”.

Discussion and conclusions

The use of blended learning has gained much acceptance in the corporate world, where it has been identified as one of the top ten trends to emerge in the delivery of knowledge and company in-house training (Bonk & Graham, 2006a). However, in higher education it has often been ignored as a way of teaching students, underutilised or badly constructed (Blass & Davis, 2003; Young, 2002), although this is changing (see Bonk & Graham, 2006b for examples of innovative blended learning projects in different countries). We found that the pilot project proved an excellent method for testing an innovative strategy whilst at the same time ensuring students learned a fundamental concept, essential to student’s success in the later years of their degree. We see the blended learning format, combining interactive online materials and followed by face-to-face follow up, as providing opportunities for deep and persistent learning, when well designed and developed. However, there were a number of limitations in the pilot, which may need to be addressed to give greater rigour to the research, for example, the students in the 2006 group may have been a better group of students, the SCORM recordings of time of access was inaccurate, and the quality of the materials produced was poor – yet the process and

findings of the study did give us some insights as to how we might improve blended learning and work better for us in our Masters program.

The results from the questionnaire indicated that the concepts of online learning were generally acceptable to our undergraduate students, providing it did not replace the normal face-to-face, but became part of a "hybrid" form of education, as suggested by Young (2002). It is certain that the flexibility of a blended approach is what our students enjoyed most, but this needs to be measured against the obvious problem that some students will either procrastinate, or not take advantage of accessing all or even just some of the materials, as happened with some of our students in the study (see also Graham, 2006). In the Masters programme we are developing, the need to ensure student engagement with the materials, and with each other, for successful learning, is paramount, but difficult considering their dispersion. We would see mobile technology, online group discussions, online tutorials, and chat rooms as ways of enabling student participation. We have also made the decision to employ tutors who will act as course facilitators, whose role will be to encourage students to use technology as a tool, to communicate with each other, and to engage with the learning tasks and activities (Segrave & Holt, 2003). Tutors will need to become 'intelligent agents' sensitive to the limitations of the technology, and encouraging synchronous, as well as asynchronous, group collaboration amongst students, mobile and geographically dispersed across the globe (Hill & Roldan, 2005).

The main issue for our pilot study, however, was one of quality of the materials. Despite our best efforts the sound quality of the recorded lectures was not high; we found that the audio was difficult to keep 'clean' from external noise. As the potential students for our Masters programme are globally dispersed, coming from a variety of nationalities (including non-English speaking backgrounds), we believe that a lack of clarity in the audio will present a problem. So we have worked around this problem, creating scripts for each of our lectures, and utilising the services of a professional voice talent, recording the materials in a studio, creating a better quality product. To ensure the quality of the materials as advised by Blass and Davis (2003) the units within the Masters programme are being developed by industry experts and academics with the help of instructional designers, who will ensure that we progress beyond the simplistic attempts to move face-to-face courses online and develop courses offering an integrated learning experience that provide learning activities to bring about the stated learning objectives (Segrave & Holt, 2003).

We have not yet completed our pilot study. One of the core problems, which originated the study, was that students had failed to grasp the material in their second year, and the lecturer had the perception that he had to re-teach the material in the third year. To fully evaluate the extend of the learning one of the questions we have raised and hope to examine this year, is how much of the learning did students retain? Was the learning deep learning, were students able to engage with the materials enough, that they were able to retain the information, and are able to apply that knowledge this year? This is a question we hope to answer. And as regards our Masters programme, our students begin in August this year. One of the questions we have is, have we done enough to ensure that our

students will be fully engaged? How will we evaluate the quality and effectiveness of the teaching and learning strategies? What changes will we need to make to the course as a whole, as well as unit content and delivery as we continue to experiment and learn? These and others are questions for the future, as we enter in Brown's words, the "brave new era of borderless learning" (2000, p. 348).

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