

# Quantum leaps in blended learning: an online project for physics students

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*Abstract:* This study followed the experiences of a group of students in a second year quantum mechanics course as they undertook a short project to develop a web site. Typically, 'blended learning' is used to refer to the provision of a mixture of face-to-face and online learning and assessment activities by the teachers of a course. In this case, it was the students themselves who were engaged in developing online resources to be shared amongst the class, and beyond.

The students worked in small groups to develop web sites introducing some aspect of quantum physics to a wide audience. The project required students to find their own topic, form their own groups, determine what would be on the web site, and agree on how they would go about creating it. Most students did not have previous experience in web design, and group members had to attend external tutorials to gain the necessary skills. The assignment was monitored through reflective diaries, focus groups and observation of online discussions.

Students found value in the assignment well beyond the developed understanding of an area of physics. They learnt useful skills in information and communication technology, including web design, they developed a stronger sense of community within their class and a stronger sense of identification and community with professional practitioners within the discipline, including their lecturers.

## Introduction

Blended learning is often portrayed as the learning that develops from experiencing a mixture of face-to-face and online teaching practices (Oliver and Trigwell 2005). Blended learning is frequently referred to from the point of view of the teacher and described as the provision of course materials, activities and discussion, in a mix of face-to-face and online environments. This study considers blended learning in which it is the students rather than (or in fact as well as) the lecturers who are engaged in producing online materials. Hence the students, rather than simply using the online materials provided for them, and interacting with each other and the lecturers online, engage in producing their own web sites. This project required the students, rather than their teachers, to combine face-to-face communication skills with a range of literature review and information technology (IT) tools to create a web site explaining some aspect of quantum physics.

The authors did not participate in the teaching of the course, although one, KW, recruited and managed those students who kept reflective journals. The course is a mathematical introduction to quantum mechanics and topics covered include quantisation and wave particle duality, operators and observables, the Hamiltonian, the Schrodinger wave equation and solutions for various cases using normalisation and orthogonality, the use of Dirac notation for operators and observables, wells, barriers, bound and unbound states. In short, the syllabus is that of a 'typical' second year quantum physics course. The mode of delivery was primarily face to face, with resources including lecture notes, problem sets and extra readings provided online using *WebCT*. There was also ample opportunity for online communication using the discussion and email tools in *WebCT*, which were used by lecturers and students.

The structure of the web site project addressed the basic tenets of case based learning as described by Bennett, Harper and Hedberg (2002; p.2), namely it '...involves complex, authentic situations in which the learner (usually a novice) must learn to think like a practitioner (an expert). This reflects a view that learning is a process of moving towards greater expertise.' The small group structure and the required development and application of IT skills resulted in the production of learning resources (the web sites) that directly modelled the processes of science communication specialists (the lecturers). The processes of blended learning were intrinsic to the task as it required research using electronic and paper based sources and collaboration within a small team. This collaboration,



occurring partly face-to-face, partly via email, partly online using the *WebCT* course environment, produced an electronic resource for use by other students and potentially a broader audience.

## The task – web design

Students were asked to prepare a web site on an aspect of quantum physics of their own choosing. Topics chosen by the students included the conflict between quantum physics and general relativity, Bose-Einstein Condensates, quantum tunnelling, the EPR paradox and the philosophy of quantum mechanics. Students self-selected teams of 3-5 and some built on a first year project in 2004 where students presented a talk or poster as part of a mini-conference on quantum physics. The feedback on that task had been generally positive, with students pointing to group work and the opportunity to explore a topic of their own choosing as things that they enjoyed and valued. One lecturer, in describing the aims of this current assignment stated:

PHYS2013 is a fast and furious course – like drinking from a fire-hose. My hope was that the web assignment might somewhat alleviate this by allowing them to develop a topic of their own choosing in depth, in a group environment. Perhaps they would then feel they understood at least one thing well. It also addressed generic learning objectives such as communication and group work, which I think are important. (Savage 2005)

The web site project was explicitly presented as a follow on from the first year mini-conference, with similar learning objectives including improved communication and teamwork skills. The main difference was the mode of communication and the intended audience. In the first year assignment, the audience was primarily their own peer group and the markers; the mode of presentation was oral or poster. In the second year assignment, the mode was the Internet and the intended audience included the public as well as their peers and lecturers, with some assumed knowledge of mathematics and physics.

The web assignment replaced two of the regular weekly problem sheets, and contributed 12% to the final course mark. Providing all members agreed, the groups were permitted to divide the group mark differentially among them, such that the average mark in the group was the group mark given by the lecturers. The lecturer suggested roles such as team leader, web designer and researcher, however few groups in practice used roles other than that of the web designer. The stated assessment criteria included: accuracy of information; depth and breadth of information; referencing of sources; effectiveness of presentation for the target audience; impact and diversity of presentation (e.g., text, images, links); and appropriateness of the presentation for web delivery. The remainder of the course assessment was individual, and included a large examination component as well as weekly problem sets.

## Research methodology

Student reflective journal keeping has been used to investigate non-science student experience of science courses (Tobias 1994) as well as the experience of science students as a course is modified and developed (Wilson and Russell 2003). In the present study, a combination of reflective diaries and focus groups were used to investigate the experience of students undertaking an unusual assignment in quantum physics.

One of the authors, KW, was given access to the course *WebCT* site and used this to monitor online discussion of the project and to recruit a group of seven students, five male and two female (from a class of 64) to assist in research and be paid a small amount to do so. These students attended two focus group meetings, one near the start of the process and one after the submission of the assignment. The students kept reflective journals for the six weeks they worked on the project, and were asked to record in their journals what they did, what they learnt, and what their thoughts and feelings were as they progressed through the project. Towards the end they were asked to summarise

what they learnt, what was good and bad about the project, what they would do differently next time and what advice they had for the lecturers and for next year's student cohort on this assignment. This second set of questions formed the basis for the second focus group meeting (moderated by KW with pizza lunch provided). The first meeting primarily addressed 'first impressions', what they hoped to learn, and initial difficulties with group formation.

Three students were from one assignment group, two were from a second group and two were from a third and fourth group respectively. This gave the opportunity to compare student experiences of the assignment both within and across groups. The students were paid as research assistants on the understanding that their diaries would be used for research purposes, but that their anonymity would be respected.

In addition, feedback was sought from the course lecturers (neither of whom was involved in data collection for this study) and from other students via *WebCT* discussion boards. Staff were asked what the intended learning outcomes were, how well they thought they had been achieved, what difficulties they perceived with the process and what they thought the students had learnt from the project. While there is a wide variety of experience recorded in the students' diaries, there are some recurring themes and patterns, as described below. Further analysis, such as the use of text analysis (see for example, Wilson and Russell 2003) will enable more quantitative findings.

## Student experiences and learning

The themes that emerged most strongly from the diaries were those of community building, both within groups and in the broader class, and the development of new skills including teamwork skills and organisational skills. While these skills emerged as a common learning theme, it was obviously as part of a sometimes difficult development process. Teamwork skills clearly were a challenge for these students. In spite of the facts that most of the students had been together in first year where they had undertaken several group tasks and worked in pairs in laboratories, they still had trouble forming groups or finding a group to join. There were a range of reasons for this: some did not know many people in the course, or felt uncomfortable approaching others in the class; some simply left it until very late to form a group and then found that most students were already part of teams. The lecturers assisted some students to find groups to join, while others made contact with others looking for a group using the course *WebCT* site. This was the most common message topic on the board related to the assignment.

In addition to forming teams, working in teams was a recurring theme in the diaries. For some teams this was a positive experience, particularly where the majority of the members were already friends. Other groups had substantial difficulties, generally due to either poor communication or poor organisation within the group. Nonetheless, most students found working as part of a team, whether with friends or people they did not know already, was a positive experience. One student commented that 'It is good to see a couple of more familiar faces in lectures'. Even those who were part of less functional groups felt that they had learnt from the experience, contributing comments on what they felt were the main difficulties and how they could be addressed in future. For example, 'I think one of the hardest things about working in a group is defining clearly what everyone needs to do to get the job done, without too much overlap'.

All of the students discussed gaining an understanding of topics in quantum physics beyond the standard course content, and they were generally positive about this aspect of the project. One student oscillated between uncertainty and seeing the assignment as a distraction from the main course content, 'There are things I enjoy about this project, but in the end it's a sidebar to the subject', however by the end of the assignment when each group's material came together, most students felt that they had indeed learnt something of value 'I felt that I learned a huge amount of good things that can come out of Quantum Mechanics... whenever [QM] is mentioned I get a lot more excited about talking about it than I used to get.' While there were some concerns amongst



students that the assignment ‘wasn’t really physics’, these were relatively rare, and tended to appear early in the duration of the project only.

At the beginning of the assignment very few students had any experience in producing web sites. Overall, these students seem to be in an intermediate generation, taking the Internet and instant access to information for granted, but not being routinely familiar with the process of creating a web site. Only one of the seven diary keeping students had produced a web site before, and this was approximately representative of the class as a whole. Many students found this aspect of the assignment worrying, in spite of tutorials being provided to help with technical aspects and *Adobe Dreamweaver* classes held by the ANU library. The lecturers identified the conflict between needing to provide support for students, and ensuring that tutorials were attended. The students themselves also identified this issue: ‘I wish now that I had gone to the *Dreamweaver* course last week but at the time I didn’t think I needed to know any more’. At the final focus group meeting several commented that it would have been good to make them attend the *Dreamweaver* tutorials even though they would probably have resented it at the time and not appreciated it until later.

The students often mentioned general communication skills. They particularly noted the need to communicate clearly and at a level appropriate to the intended audience. As one student commented, ‘I enjoyed the opportunity to go beyond the equations and actual physics in the writing/design involved in the communication of science through the web site.’ Most students were concerned about making the sites interesting and appealing, and were aware early of the conflict between the need to provide enough information without the level of detail and complexity becoming too great. Some students drew on their experience of the first year mini-conference in this task:

The other people in my group did first year physics two years ago, and so they missed out on the mini-conference last year. That means that they missed out on the experience of working in a team, and writing things which keep anyone interested (not just the markers). I think one of the best things to come out of a project like this is the ability to tell the same story in different ways.

One of the themes that emerged in the first focus group meeting was that of ‘giving back’ and engaging in a dialogue with their lecturers. The students described the web site as another way of communicating with their teachers; the assignment provided a means of conveying their understanding of the topic not generally afforded by more traditional assessment tasks such as problem sets. The problem sets were not viewed as allowing real communication with the lecturers, in a personal way, given that they each gave (or were expected to give) the same response. By contrast, this assignment was recognised as giving them an opportunity where ‘we have to represent what we’re learning in our own way’, and which ‘lets them know where we’re coming from’.

A pleasing outcome of this assignment (and unexpected from the lecturers perspective) was the value students found in the growth of a community of interest. This initially developed within and between groups, and was fostered by seeing the web sites produced by other groups. Over time, students enlarged the view of their community of practice to include the academic staff and other professional practitioners. Students remarked on the potential value of their web sites as a resource to the Department and the broader physics community. One student commented in the first meeting that the assignment filled a ‘need to contribute something back to the Department, they’re getting something out of us in return’ and that ‘it’s beneficial for science in the long run’.

Finally, the students appreciated the break from weekly problem sheets accorded by the assignment. Comments supporting this variation in task were made in all diaries, and several times in each of the focus group meetings. In summary, the great majority of students found the project worthwhile in terms of both the quantum physics and the skills that they learnt through it, even when the journey itself was at times difficult:

It's funny to look back and think about the panic I was in 2 week ago over this project. I've definitely learnt a lot during the course of this assignment, about time and studying and teamwork. Also about leadership. ...I've learnt about string theory, loop quantum gravity, the conflict between relativity and QM. And I've learnt how to create a web site. Good work.

## Implications

The project achieved the goals of the lecturers, which were to extend and deepen discipline knowledge, teamwork and communication skills. From the lecturers' perspective, the students practised and improved their teamwork skills. They developed web sites that were, on the whole, successful at communicating an aspect of quantum mechanics in an interesting and engaging way and at an appropriate level to the target audience. The use of the completed web sites in first year physics courses may be an important motivator to the second year students in striving for a high standard of project. Feedback from the first year students might also be a component of the assessment of the sites. From the point of view of the web site development groups, this feedback from an audience of end-users could provide valuable recognition that the assignment has intrinsic value outside their own learning. The feedback could help answer the question 'Does the web site really work?' One student did this independently and noted that it was a useful activity.

Lecturers also need to consider that despite many of the students having experience in group-based projects it is clear that the development of these skills requires more practice and perhaps specific training or intervention. At this stage in their education these students recognise the value of teamwork and project management but often the lacked the skills or motivation to put these understandings into practice. Phillips and Luca (2000) explicitly taught project management models to students working together face-to-face and via *WebCT* to teach students how to manage the development of multimedia projects. Just as the lecturers offered tutorials on *Dreamweaver* skills, some explicit training in teamwork and project management could be offered or even required of the students at the start of the assignment.

From the students' perspectives, the assignment was seen as a bridge-building opportunity that opened a dialogue with their lecturers while also increasing communication between their peers. In effect, the project allowed the students to make a foray into the professional community. An implication is that explicitly including an expectation of public access to the final web sites in the project requirements may increase the students' sense of becoming valued members of the professional community. This is an important part of the induction of undergraduates into the academic experience in an education intensive research university.

The students recognised skill development, specifically IT and communication skills, as a major and valuable outcome of this project. They also clearly recognised that discussion with other students in a social context built discipline knowledge. These communication skills were important for the development of a community of practice within the student body as well as between students and lecturers. Diary entries showed students valued the change of view of self from student (as passive receiver of information) to apprentice (beginning practitioner).

When asked what they would do differently next time, or what advice they would give to next year's cohort if the assignment was given again, most of the students said that it would be wise to start earlier, establish good group communication, organise tasks well and perhaps even choose a group leader to keep the process on track. Organisational skills appeared to have grown in value to these students during the course of this assignment, although of course it remains to be seen whether these lessons are remembered the next time these students are faced with such a task!

One student diary aptly summarised the main advantages of the assignment as:

... a great way to make new friends; interesting way to develop understanding of QM; an opportunity to gain valuable skills in web authoring; a way to give something back to each other



as well as lecturers and ANU, if not outside community; and simply a nice break from numbers upon numbers in weekly assignments!

Finally, while the students made great use of the processes of blended learning in this web site project, from their perspective they were just 'learning'. The tools of blended learning retain some novelty for many tertiary teachers, but they are being applied to a generation of learners who have never known a world without them. The use of a tool set including face-to-face and online communication, library resources (both hard copy and electronic), and web resources to produce an online resource with the attributes that are distinct to the online environment was unusual to these students, but only from the perspective of having to generate the resource themselves. For teachers, we hope the focus remains on learning and the term 'blended learning' is soon redundant; this would imply that teachers are skilled enough to take advantage of the full range of teaching tools available to them today, and not just the set they were exposed to when they were students.

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