Leveraging the online environment to remove barriers to student learning in large first year foundation subjects

Emma Yench and **A. Crosky**, School of Materials Science and Engineering, The University of New South Wales, Australia
K. Wilk, School of Physics, The University of New South Wales, Australia
and
B. Allen, Learning and Teaching @UNSW, The University of New South Wales, Australia
e.yench@unsw.edu.au a.crosky@unsw.edu.au k.wilk@unsw.edu.au belinda@unsw.edu.au

Introduction

Background to project

This work is part of a larger three year project aimed at disseminating good practice in online learning and teaching throughout the Faculty of Science at The University of New South Wales (UNSW). Dissemination is based on a template *Blackboard Vista* site created for a large first year Materials Science course (Allen, Crosky, McAlpine, Hoffman and Monroe, 2006). A project group comprising members of several schools in the Science Faculty has been formed to manage the overall project and project funds have been used to employ an educational developer to work with academic teaching staff to modify and implement the template into courses from different schools across the faculty. The focus of the group is on large classes with a view to getting maximum impact (improved outcomes for the largest number of students). *Fundamentals of Physics* is one of the first courses to modify and implement the template as part of this project.

The current situation

Fundamentals of Physics is a large first year course for students not intending to continue in physics (service course). Students do not generally have a background in physics and take this course as a prerequisite or elective for other degree programs. It is comprised of a series of weekly three-hour lectures covering basic concepts, supported by weekly one-hour tutorials and two-hour laboratory classes that demonstrate relevant concepts.

The laboratory classes are run as nine two-hour laboratory sessions. Each laboratory is designed to introduce a different topic, each related to a specific topic covered in the lectures. Due to time and facilities constraints, it is not possible to conduct the laboratory experiments after the lecture material for all students. To redress this issue, introductory exercises are provided for the students to complete prior to the experiment so that they arrive at the laboratory prepared with an understanding of the relevant theoretical concepts to be applied in the experimental work.

The assessment for the course is 25% for laboratory work, 15% for lecture and tutorial related quizzes plus 60% for mid and end of session examinations. Marks are awarded in each laboratory session by demonstrators for the pre-laboratory exercises, and the laboratory experimental work. The pre-laboratory work is marked only during the first 15 minutes of the laboratory time. Currently students receive a mark out of four for each session, comprising one mark for completed pre-work and three marks for the laboratory experimental work which must be completed and presented for marking no later than 15 minutes before the end of the laboratory session.

The course instructors have identified a number of issues, particularly relating to laboratory work, that need to be addressed. These are:
1. comprehension of content for physics novices;
2. student engagement, particularly for non-continuing students;

3. the impact of administrative logistics on the learning and teaching experience where large numbers of students must access limited human and material resources in limited time; and
4. maintaining a consistent quality of instructional approach and feedback when working with large numbers of tutors/demonstrators.

To further explore this, the students were asked at the end of the course in June 2008, to complete a survey to gauge their perception of the issues and challenges for student learning. The paper survey was handed out and collected by an administrative officer before the end of class. Consequently, the response was 80%, with responses from 144 out of 178 students, providing a robust representation of student views. Comments were also solicited in an online forum. A structured, recorded focus group was also conducted with the demonstrators. The feedback obtained related to student engagement, laboratory preparation, acquisition of concepts, limitations of time and resources, effective and consistent feedback and reflective learning.

Student engagement

As commonly experienced in first year service subjects, students come to the subject from a wide variety of backgrounds in different discipline areas. Demonstrators indicated that many students do not expect to use physics in their degree, are taking the course for extrinsic reasons (e.g. perceived as an easy course to pass), and are content to achieve a pass with minimum effort. Students are very grade-motivated.

> ‘I had one student hardly attempted the pre-lab and he just didn’t care really, I mean he was happy just [to get] two every time. I think one of the reasons was because this was an aviation student and they don’t need this subject as a prerequisite for anything else, they just need to pass.’

Laboratory preparation

Pre-laboratory theoretical exercises are set for each laboratory, but students often arrive at laboratory sessions unprepared or ill prepared. Most make some attempt but many have not completed the work adequately, and some copy their work from other students before or during the laboratory session with little understanding of the underlying concepts. They then struggle to comprehend the laboratory work.

When surveyed, 79% of students indicated that their attempts at pre-laboratory exercises were incomplete, or completed only with assistance from other students or demonstrators. Independently of the student survey, demonstrators estimated that up to 75% of students do not have an adequate grasp of the relevant theoretical concepts before arriving at the laboratory.

Acquisition of concepts

The content of the subject seems to present significant difficulties for students. 66% indicated that concepts in physics were difficult to understand. Mathematics competence was also a factor identified by demonstrators and by some students.

> ‘course is too hard for fundamentals – pre-lab usually required difficult maths that hasn't been explained in lectures’

The laboratory manual for *Fundamentals of Physics* is adapted from a higher level physics class and does not always present concepts at a sufficiently introductory level. 68% of student surveyed did not agree that the laboratory manual instructions were clear and easy to understand. 55% found the pre-laboratory exercise difficult to understand with a further 30% remaining neutral; only 24% of students felt confident in their responses to the pre-laboratory exercises.

Demonstrators expressed frustration that students did not grasp basic skills early enough in session (term) and commented that the laboratory and pre-laboratory work could be improved by introducing, and more consistently building on, basic skills throughout the session.

Limitations of time and resources
Only 19% of students felt that they had sufficient time in the laboratory to complete the experiments and discuss the results.

> 'overall I felt that the time allocated is too short. Consider cutting some pracs down. However, pracs illustrated lecture material'

Demonstrators also identified time constraints as a factor. Marking time, both before and after the experiment, reduces the two hour laboratory session to one and a half hours effective working time.

Effective and consistent feedback
Also due to time and facility constraints, laboratory sessions run back-to-back, reducing demonstrators' ability to check individuals' pre-laboratory and laboratory work thoroughly and provide useful relevant feedback. Demonstrators find they do not have time to provide individual in-depth feedback to students. Students indicate that the quality of explanation and marking also varies across the demonstrator staff:

> 'It is COMPLETE pot luck about what marks you will get due to tutors. I have learnt to target specific ones who mark accordingly and will actually provide help.'

Reflective learning
Presently students have little opportunity to engage in in-class individual or group reflective discussion about laboratory results and the concepts that underpin the work, as demonstrator time is taken up marking work, and student time in returning equipment.

Students have attributed this to the time constraints.

> 'I felt that I did not have enough time in the lab to really develop my understanding of the concepts and learning outcomes as there is not enough time allowed for answering questions if you want to write more than a yes or no answer. This also applies to writing up conclusions and discussion.'

Proposed design solution

Based on the identification of the above issues, we decided to adapt the template with emphasis on redesigning the pre-laboratory exercises into assessable interactive online modules. The concept of these modules is based on the successful implementation of online tutorials in Materials Science (Box, Munroe, Crosky, Hoffman, Krauklis and Ford 2001) which were already present in the *Blackboard Vista* template.

Accordingly, each laboratory unit will form a learning module comprising three parts: Pre-laboratory exercises, laboratory experimental works and post-laboratory exercise.

Pre-laboratory exercises
These comprise a set of online pre-laboratory exercises containing interactive activities and formative questions testing student understanding at each point, and including a short summative quiz to test understanding. The quiz will be made available to students a week before their scheduled laboratory session and will become unavailable thereafter. However the exercises will remain available indefinitely for revision of content.

Laboratory experimental work
Experimental work will remain almost the same as it currently stands.

Post-laboratory exercise
The theory presented in the exercises will be integrated with the experimental work by the addition of a brief post-laboratory quiz designed to reinforce the basic concepts. This quiz will not become available until after completion of the pre-laboratory exercises and quiz, and the experimental work.

A small number of marks will be awarded for each section, with automated marking of pre-work, removing the need for demonstrators to mark pre-work.

It is expected that each module will be able to stand alone in the presentation of basic concepts in recognition of the fact that students must often attempt modules and laboratories before attending scheduled lectures on related content.

Discussion

Biggs (2002) discusses the need to align online activities with course assessment tasks so that students find it difficult to ‘escape’ without achieving the intended learning objectives. This approach is supported by our own observations of student motivation in this course and consequently we determined that any changes we made must be tightly integrated into the course assessment. The resulting design of the online pre- and post- laboratory exercises takes advantage of the features of the *Blackboard Vista* Evaluation tool to maximise the motivation to complete the work. For each topic, pre- and post- laboratory exercises are presented as a single online module. Post-laboratory exercises are set to become available upon submission of the pre-work section of the module. Non-completion of pre-work will mean that post-laboratory work will not become available, resulting in a loss of marks for both pre and post laboratory work components (which will record an overall fail for that topic regardless of whether the student has attended the laboratory).

Throughout this project a subject novice (educational developer) has worked closely with the subject expert (course instructor) to identify common misperceptions and difficulties and develop activities that proceed at a level appropriate for a subject novice. According to Schulman (1999), ‘Learners construct meaning out of their prior understanding. Any new learning must, in some fashion, connect with what learners already know’.

In this instance, students have no prior experience with the subject matter, so wherever possible exercises are presented in the context of real-world examples (e.g. playing golf in a thunder storm to illustrate the properties of an electrostatic field) in order to engage students with the content based on their lived experience (Reeves, Herrington and Oliver 2002).

Studies into intrinsic cognitive load indicate that humans can effectively process only two to three different novel interacting elements at once (Paas, Renkl and Sweller 2003). Accordingly, activities are designed to incrementally build student familiarity with, and understanding of, basic concepts and, via the use of co-ordinated student controlled animations, explicitly illustrate the interrelationships between observable phenomena, and the different representational descriptions (e.g. diagrams, graphs, formulae) of those phenomena. This use of animation has been shown in a number of studies to improve student learning (Ardac and Akaygun 2004; Talib, Matthews and Secombe 2005).

Bonwell and Eison (1991) point out that students learn most effectively when actively engaged in higher order thinking tasks. Consequently, the exercises are designed to actively engage the students in their own learning by providing control over animations, and requiring interaction and thoughtful responses in order to reach completion.

The overall structure of each module is based on an Engage, Explore, Explain, Extend and Evaluate (5Es) learning cycle for science instruction described by Lorsbach (online). Short post-laboratory quizzes have been developed to build on pre-laboratory theory and laboratory experiential work and extend and reinforce students' understanding. They review basic concepts and require students to apply their understanding to a new scenario assisting students to successfully integrate theory and apply it to a novel situation, thus completing the learning cycle, and reinforcing new knowledge. We also see this as an opportunity to provide students with more feedback and for students to reflect on their learning. (Herrington and Oliver 2002).

According to cognitive load theorists, when intrinsic cognitive load is high, as it is in the acquisition of interrelated physics concepts for novices, poorly designed instructional resources can place further unnecessary cognitive load on students, which can interfere with the acquisition of conceptual understanding (Paas, Renkl and Sweller 2003). In this project, the instructional design process involved moving the pre-laboratory exercises from the manual to an online environment. Accordingly, this has required analysis of the student workflow to ensure that online activities are well integrated with face to face activities to avoid placing extraneous cognitive load on students. For example, drawing graphs of theoretical results for comparison with laboratory experimental results is a necessary component of a number of topics. It became clear that this could not reliably be handled online when the results were required in class, so it was determined that the best approach would be to require the graph to be drawn in the laboratory class or drawn and brought to the laboratory class as had been done previously. These activities remain in the laboratory manual and students are referred to them from the online module.

Implementation and evaluation

Initially we are developing a set of two to three modules for implementation in Session 2 in 2008. Pending a successful implementation, it is expected that further modules will be developed to cover all laboratory work for this course.

Students have been surveyed at the end of the current session (Session 1, 2008) and their responses used to guide the design of the modules. Students will be surveyed again at the end of Session 2 2008 using the same survey instrument. The modules will only be used for the second half of the course, so that the students will experience both the old and the new formats. Each module will also contain a short voluntary survey to gain student feedback on the individual content of each module, which will be used to modify and improve the modules in the future.

Demonstrators have also been interviewed for their feedback about the current and proposed systems and their feedback has been incorporated into the design. They will be interviewed again after the implementation.

Finally, aggregate student laboratory grades for the relevant topics for Session 1 will be compared with those from Session 2, 2008.

Conclusions

In an era where classes are getting larger, and universities are experiencing stress on human and all other resources, impacting in turn on the quality of student learning, it seems imperative to get the best possible use out of the online environment in ways that are appropriate to the course. Using the provided course template, modified to suit the particular needs of this first year service subject, we hope to develop a solution that improves the learning experience for students in physics at UNSW.

References

Allen, B., Crosky, A., McAlpine, I., Hoffman, M. and Munroe, P. (2006) A blended approach to collaborative learning: Can it make large group teaching more student-centred?, *Proceedings, 23rd ASCILITE Conference*, Sydney, December 2006, 33–42.

Ardac, D., and Akaygun, S. (2004) Effectiveness of Multimedia-based Instruction That Emphasizes Molecular Representations on Students' Understanding of Chemical Change. *Journal of Research in Science Teaching*, **41**(4), 317–337.

Biggs, J. (2002) *Aligning Teaching and Assessment to Curriculum Objectives* [Online] Available: http://www.itslifejimbutnotasweknowit.org.uk/Files/CPLHE/Biggs%20Constructive%20alignment.rtf [2008, June 20].

Bonwell, C.C. andEison, J.A. (1991) *Active Learning: Creating Excitement in the Classroom*. Washington, DC: ERIC Clearinghouse on Higher Education, The George Washington University.

Box, V.J., Munroe, P.R., Crosky, A.C., Hoffman, M.J., Krauklis, P., and Ford, R.A.J. (2001). Increasing student involvement in Materials Engineering service subjects for Mechanical Engineers. *International Journal of Engineering Education*, **17**(6), 529–537.

Herrington, J. and Oliver, R. (2002) Designing for reflection in online courses. *HERDSA 2002 conference proceedings* [http://www.ecu.edu.au/conferences/herdsa/main/papers/ref/pdf/HerringtonJ.pdf].

Lorsbach, A. *The Learning Cycle as a Tool for Planning Science Instruction* [Online] Available: http://www.coe.ilstu.edu/scienceed/lorsbach/257lrcy.htm [2008, June 20].

Paas, F., Renkl, A., and Sweller, J. (2003) Cognitive Load Theory and Instructional Design: Recent Developments. *Educational Psychologist*, **38**(1), 1–4.

Reeves, T.C., Herrington, J. and Oliver, R. (2002) Authentic activities and online learning. *HERDSA 2002 conference proceedings* [http://www.ecu.edu.au/conferences/herdsa/main/papers/ref/pdf/Reeves.pdf].

Schulman, L. (1999) Taking Learning Seriously. *Change*, **31**(4), 12. [Online] Available: http://www.carnegiefoundation.org/elibrary/docs/taking.htm [2008, June 20].

Talib, O., Matthews, R., and Secombe, M. (2005) Constructivist Animations for Conceptual Change: An Effective Instructional Strategy in Understanding Complex, Abstract and Dynamic Science Concepts. *Malaysian Online Journal of Instructional Technology*, **2**(3), 78–87.

Yench, E. Crosky, A., Wilk, K. and Allen, B. (2008) Leveraging the online environment to remove barriers to student learning in large first year foundation subjects. In A. Hugman and K. Placing (Eds) *Symposium Proceedings: Visualisation and Concept Development*, UniServe Science, The University of Sydney, 214–219.