The first year Physics online diary project

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Abstract

This article considers the laboratory learning experiences of first-year physics students at The University of New South Wales (UNSW). The data was gathered by online student diaries, with a range of questions completed at weekly intervals over three semesters, plus focus groups. Data from large scale surveys of students was used to supplement and provide context for the data provided by the group of diary keepers. The textual data from the diaries was analysed using NVIVO. Based on the data collected the existing laboratory courses were modified using an action research approach over three semesters.

Introduction: context for the diary project

Perceived shortcomings in approaches to teaching first-year Physics led to a proposal to investigate students' experiences in physics classes. Anecdotal evidence from teaching staff indicated that they were dissatisfied with student performance and attitudes in some parts of the course, in particular tutorials and laboratories.

All courses have standard multiple choice student satisfaction surveys administered at the end, and generally the first year Physics courses rated on a par with other science subjects. However these sorts of simple student feedback surveys may fail to give any meaningful insight into students' learning experiences. Hence it was decided that an in-depth study of the student learning experience in first year physics should be carried out.

The study looked at all aspects of the physics courses, but focussed in particular on the laboratory course for several reasons. First, the laboratory course is the most expensive component of any traditional physics course, requiring high staff to student ratios, equipment, maintenance, space, and specialised support staff. Secondly, the laboratory course is common to most first year Physics courses at UNSW, so making improvements in the laboratory course will benefit more students than making changes in individual lecture courses. Thirdly, the laboratory course is largely independent of lecture courses, and is not 'owned' by separate academic staff, hence modifying the laboratory program involved far less change management than modifying any other aspect of the courses.

Informal feedback from students showed that students considered the laboratories easy marks, and generally neither challenging nor engaging. This impression was supported by discussions with the demonstrators. There is a growing body of literature suggesting that traditional 'cook-book' style laboratories may not be the most effective way to engage students nor the most effective for their learning. See for example Abbot, Saul, Parker and Beichner (2000), Van Domelen and Van Heuvelen (2002) and Kirkup, Johnson, Hazel, Cheary, Green, Swift and Holliday (1998). Redish (1999) reports very significant improvements in physics learning by replacing lectures with a guided discovery workshop approach. The workshop physics approach combines brief lectures, small group experimentation and class discussion, using open-ended problems as well as those that have specific numerical solutions (Redish 2002). These approaches emphasise group work as an integral part of the learning process with the aim of encouraging the development of communication and teamwork skills while leading to a deeper understanding of and greater engagement with the science. A problem-solving model for Physics courses developed by Heller and Heller (1999) emphasises cooperative group work in solving context-rich problems. The guided discovery approach described by Redish (2002) and the Technology Enabled Active Learning (TEAL) approach developed at MIT (Belcher 2001) all emphasise small group learning activities. The TEAL approach makes extensive use of technology to support small group experimentation, and to communicate results to the whole class.

Prior to the beginning of the diary project, several large scale surveys of students' expectations and experience of the laboratory project were carried out. These provided further evidence that students expected and *wanted* to be more challenged in the laboratory to design and interpret experiments than was actually the case. In addition, students and staff were surveyed on what they believed the most important aims of the laboratory program should be. This set of data, reported in Wilson and Hunt (2002), revealed a mismatch between staff and student expectations and values. These preliminary results led to the design of the Physics Diary Project, which is described below.

The first year Physics Diary Project

Overview of methodology

Overall, this was a phenomenological enquiry applying a student-centred approach, informed by the work of Biggs (1999). The methodology broadly follows an action research approach for higher education, in which there are repeated cycles of action, observation, reflection/analysis, and planning for the next semester's activities (Zuber-Skerritt 1992).

The qualitative data, in the form of typical quotes from students, and their suggestions for additional survey questions, led to survey revisions in semester 2 and provided a cross-check on the quantitative data. So although it could not be analysed rigorously before semester 2, it still led to new activities and an expanded evaluation, in keeping with the action research approach.

A detailed analysis of text to find emergent concerns in the first semester of 2002 laboratory experiments informed experiment design for the first semester of 2003. Further analysis of the combined semester 1 and semester 2 feedback has built up a picture of student learning patterns in first year Physics as a whole. This provided more extensive and rigorous data – by identifying which learning issues students mention most frequently. These are being built into future routine evaluations.

In addition to open ended questions a small number of multiple choice Likert scale questions were used each week, asking the students to rate the conceptual and technical difficulty of the experiment they did as well as how interesting and how enjoyable they found it. This provided quick, quantitative data that could be correlated with the lengthy written responses.

Figure 1 gives an overview of the action research cycles.

The students

Each semester students were recruited through notices asking for volunteers. A nominal payment to compensate for the time involved was offered as an incentive. Those selected were from a range of courses, roughly representative of numbers of students in the different courses, although there was a slightly higher proportion of physics majors in the diary group than in the overall first year population. The gender ratio was also approximately representative of that in first year physics, being predominantly males.

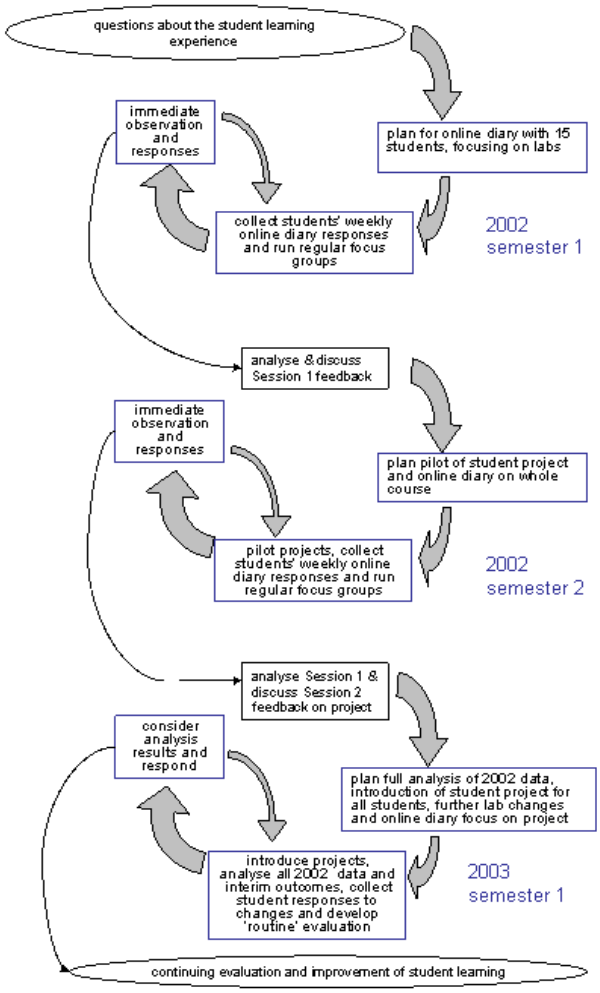

Figure 1. Action research cycles in the UNSW first Year Physics diary project

In semester 2, three of the 15 students from the first semester project group were retained, and another 11 students from a range of courses were recruited. Two of the three students retained from the first semester were in the course with the modified laboratory program in second semester. In 2002 students were only selected from courses which were not taught by the investigators, and students were assured that their responses would be kept anonymous.

In 2003, more students were recruited in a similar way, but with the constraint that students were only selected from subjects in which the modified lab program had been introduced.

Use of *WebCT* as an online diary

WebCT was used for a number of reasons. First, it is the internet course environment used at UNSW, so students were already familiar with it, and comfortable with using various features such as the survey and communication tools. It was also easy to create a 'dummy' course and enroll the student participants into the course.

Second, the survey tool could be used to gather lengthy text responses to open questions, such as 'what did you learn in lab this week?' and 'What helped you to learn?' in electronic form so that text analysis could be carried out

without the need for data entry. This is a major advantage over having students complete a paper journal, which subsequently needs to be carefully transcribed by a researcher who must grapple with difficult to read handwriting.

A disadvantage is that students are limited to completing their diary entries only when they have internet access, however this did not seem to be an issue for the students who contributed to this study. Internet access is widely available on campus, and most of the students involved in the project had internet access at home. The flexibility of the online diary was particularly valuable to researchers, as it enabled the student responses to be viewed at leisure, without having to collect and return paper-based diaries.

Two or three meetings were held during each semester where students were asked to reflect informally on their experiences over lunch or morning tea. These sessions gave immediate feedback for adjusting the online surveys, for example developing new questions. Students interacted and 'compared notes' on their courses, which led to interesting discussions and often raised issues which had not been previously identified. This generally led to additional questions being built into the survey, and occasionally to further discussion on the online discussion.

However, while focus groups provide relatively quick feedback, they may not on their own provide as complete a picture of student experience as an anonymous and 'impersonal' feedback mechanism such as the online diaries. For example, quieter students, or those whose first language is not English, may find that the online diary gives them time to reflect and prepare a response, whereas in a focus group the confident and gregarious may dominate (Salmon 2000). It was noted that the students who complained online of most difficulty with understanding course content were generally quietest in the focus group meetings.

Analysis of feedback

Analysis method

The greatest advantage of using *WebCT* for data collection was the removal of the need for data entry on the part of the researchers, a very substantial saving in time. As student responses were gathered, multiple choice questions could be used to supply quick, quantitative data. However the vast bulk of responses collected were open text responses which varied in length from one or two words to over a page in response to a single question. In all, over 300 pages of text responses were collected.

These responses were analysed using the *NVIVO* text analysis software. The text was coded manually on learning topics and learning issues – initially basing the codes on the students' own words and grouping these into themes as patterns began to emerge. The software allows exploration of the frequency of like comments – for example, the balance of positive and negative comments about the role of tutors, or the identification of the most common learning issues. Although the analysis process may have missed a few comments, the pattern of comments is likely to be reliable, especially for those issues where there were no specific question prompts.

The diary project ran for three consecutive academic sessions and, with each iteration, the questions became more focused on the concerns already identified, while still offering scope for open comment. An advantage of using the *NVIVO* software was that, increasingly, the question structure could be used to code these responses automatically.

With a large and continuing survey, using the *NVIVO* software to analyse online diaries would reduce manual analysis work. However, ongoing qualitative analysis in this depth may have limited returns in relation to the time and costs.

In this context the main advantage of using the software was in providing systematic and quantified evidence in a discipline where practitioners are unfamiliar with qualitative methods – without restricting the initial research to multiple choice questions. Future multiple choice questionnaires can now be focused on issues that students themselves have raised in this context, rather than on the initial assumptions of their teachers.

Results from the diary project

In 2002 semester 1 the questions focused mainly on the laboratory experiments. An initial analysis related issues arising to particular experiments, and informed some changes made in semester 2. These changes included the introduction of open ended group laboratory projects for a single class of students, one of the outcomes described below. The semester 1 surveys also included some feedback on other course activities. In 2002 Semester 2, the questions covered all learning activities including the group projects. In first semester 2003 the diaries focussed largely on the group projects and looked to compare the learning outcomes from the projects to the normal laboratory course. In all semesters, students also mentioned learning issues that were not specifically prompted by the questions. These offer further insight into how students actually experience the learning process as a whole, and how they manage their own learning.

In semester 1 2002 the most commonly mentioned learning issue was equipment, both in terms of problems in the laboratory and in terms of what was learnt – i.e., learning to use equipment. Students generally responded to questions asking what they had learned in terms of specific content and measurements. Students also commented frequently, and generally negatively, on their level of engagement. Most students found the laboratories not challenging enough (while some added that they still wanted 'easy marks'). Other themes which emerged were peer support, they generally found working in pairs or threes positive, and interaction with the demonstrators was generally positive although many students reported not being able to get enough help from demonstrators due to time constraints.

Similar themes emerged in semester 2 2002, from the students doing the normal laboratory program. The students doing the lab group projects generally reported much higher levels of engagement and challenge. They also talked about

overcoming problems, both technical and organisational, to achieve what they wanted, and the satisfaction that they felt when they solved these problems. There were many comments on group dynamics, and while problems were reported early in the projects, these were generally resolved by the end.

In semester 1, 2003 most of the students in the diary project were doing group projects. This semester there were more problems reported, in particular with group dynamics, indicating that students needed more support or training for working in groups. Learning outcomes reported in this semester were more commonly related to team work, organization and communication, as well as problem solving. There were very few complaints of lack of challenge or boredom. Some students however found the lack of direction or instructions somewhat confronting initially.

Table 1 summarises the frequency with which students mentioned various learning outcomes without being prompted, or in response to open questions about learning, in the three semesters of the diary projects

Table 1. Ranked learning topics by session

Semester 1 2002 standard lab	Semester 2 2002 some projects	Semester 1 2003 projects
Using equipment 25	Teamwork 10	Teamwork 30
Learnt nothing 24	Research skills 9	Organisation 26
Relate theory to practice 22	Organisation 8	Research skills 18
Maths for physics 13	Relate theory to practice 8	Communication 15
Experimental error 12	Using equipment 8	Problem solving 14
Teamwork 4	Problem solving 7	Learnt nothing 8
Experimental method 4	Learnt nothing 7	Relating theory to practice 5
Organisation 2	Communication 5	
	Maths for Physics 1	

Outcomes from the diary project

The results described above resulted in many discussions amongst staff on the purpose of various course components and whether these purposes were being achieved. In particular, the findings raised concern over the apparent lack of development of generic skills such as problem solving, teamwork and communication skills which it had been assumed were being developed through laboratory classes, and to a lesser extent in tutorials. This prompted a closer look at the laboratory course, and some modifications to the program on a trial basis in semester 2, 2002, and then on a more extensive basis in 2003. The result that overall the students were not finding laboratory classes challenging enough, has resulted in a further look at individual experiments.

The immediate outcomes from the online diary feedback from 2002 were:

- the introduction of open-ended research-based laboratory projects as a pilot study with a small group of students in session 2, 2002;
- evidence of the value of the laboratory projects piloted in semester 2, supporting their introduction for all students in 2003. Laboratory projects are now offered to all physics students undertaking the full laboratory component of the course;
- evidence of the value of the laboratory projects to the larger cohort of students, however it highlighted the need for careful consideration of how such activities be scaled from small pilot classes (< 100 students) to larger numbers (>600); and
- recognition of the need to undertake ongoing evaluation of student response to courses and course components. An efficient method for obtaining feedback from students is currently under development.

Conclusions

Analysis of the student diaries revealed such patterns as lack of student engagement, alienation and loss of interest. The diary project has significantly changed the way in which the laboratory component of UNSW first year physics courses is delivered. Dialogue with students has enabled the identification of problems commonly perceived by the first year student cohort, and the monitoring of their reaction to changes introduced as a result. The success of the changes to the laboratory programme has led to plans for a much wider reshaping of the first year physics program. An additional outcome of the diary project has been an increased focus on educational research within the School of Physics.

The diary project was valuable as a one-off exercise in evaluating student experience of the existing courses and for investigating the efficacy of newly introduced activities. However the resources and support required to run the online diary project and carry out the thematic analysis of text responses are perhaps not justifiable as an ongoing exercise for routine evaluation. However, at a time when the curriculum is being reviewed it provided useful information for redesigning some aspects of the course, and identified issues for ongoing evaluation.

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