STUDENT USAGE OF WEB-BASED RESOURCES FOR ENGINEERING TEACHING

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Abstract

This paper discusses the evaluation of a learning and teaching related project. The project involved developing a set of web-based resources within the virtual learning environment WebCT [10]. The resources were used for undergraduate engineering teaching. The focus of the paper is on two main aspects: (i) Did the additional web-based resources improve student learning? and (ii) Which resources did the students use and why? Various tools for evaluation were used to obtain feedback from the students of their experience of using the web-based resources. Conclusions are drawn from this feedback as to where the lecturer can most effectively use their efforts to enhance student learning when developing web-based resources.

1 Introduction

It is well recognised that, within the UK, university engineering education is suffering from two principle problems. Firstly, fewer people are taking A Level Mathematics (e.g. [1]), which is a prerequisite for many traditional engineering degrees. Secondly, there are fewer applicants for university engineering than previously [2-5], despite the fact that there are more places on offer. Both of these problems taken together mean that there is a larger proportion of weaker students commencing degree programmes with less ability in mathematics [6-8].

This trend has been known for at least a decade now. However, it is the authors' opinion that, the style of teaching adopted within many universities has fundamentally changed little to address this issue. There needs to be consideration and adjustment of the pedagogical approach used to help these students cope with the traditional highly mathematical course material.

This paper looks at a project undertaken at the University of Sheffield to investigate which forms of web-based resource either help the students to adopt better learning practises and hence learn more effectively or simply are popular. The key novel contribution of this paper is the evaluation of the students’ experiences and also their behaviour when interacting with the resources provided. It is felt that this information will be invaluable to other lecturing staff thinking about developing web-based resources for engineering teaching. The feedback obtained highlights which resources are well used and effective and which are less well used or less effective.

The paper is organised as follows. Section 2 gives a brief outline of the background to the project and the thinking behind why the resources were developed. Section 3 gives an evaluation of students’ experiences and Section 4 of students’ behaviour. The paper finishes with conclusions.

2 Background

This section gives an overview of the motivation for the project, the module selected, how pedagogy influenced the decisions taken and also the impact on academic staff.

2.1 Motivation for the project

The project was motivated by poor performance and lack of motivation in first year engineers. The idea was to use a single module as a test case for innovative use of a virtual learning environment, WebCT [10], to support teaching and learning. Following evaluation of the project, any successful components could potentially be rolled out to other modules. The project commenced in Autumn 2002 and the final part of the evaluation study was in January 2004. Two cohorts of students used the new resources, that is semester 1 of Autumn 2002 and Autumn 2003.

2.1 Module context

The module used for the project was a compulsory module for first year systems engineers. (Although similar resources were also used to some extent on other modules, these have not yet been formally evaluated.) The module is entitled systems modelling and is taken in the first semester of an undergraduate programme. As such it is one of the first six modules encountered by the students and hence is at a time when the handling the transition from school to university is a major challenge for many.

Following a recent internal review it was decided to acknowledge that the first semester is an important transitional time and hence not to overload students with too much technical content. As such, this module is restricted to: (i) first and second order modelling, predominantly of
electrical circuits and simple mechanical systems but also with a few illustrations outside of this; (ii) an introduction to time series models. It is recognised that students may not have encountered much calculus at this stage and hence simulation of the models is left until a semester 2 module.

As is fairly conventional in the UK, the module is delivered as two lectures per week over 12 weeks and an exam is taken in the remaining part of the semester.

2.2 Pedagogical issues

A major difference from school is the relative paucity of contact with the teacher, due to class size, and the corresponding reduction in feedback. Students do not expect either to get regular and rapid feedback on their work. Also, it is difficult for the lecturer to have a clear idea of who is performing well and who is not working hard enough. This unfortunately means that students lose the pressure a school teacher can bring to bear – it is harder to hide in school. As a consequence, many students do not work hard enough being heavily distracted by the social attractions of university combined with new freedom from parental observation.

It is therefore of prime concern to the department, particularly in the first semester, that some help is given to the students to encourage them into adopting good learning practices. This can be achieved partially by weekly meetings with the personal tutor but that alone is insufficient.

One might think that students need to be enthused by excitement for the topic itself and then they would want to work harder, however this is probably flawed logic in general. Of course some lecturers do enthuse better than others but the impact on self-study is probably small. Instead the approach taken here is to argue that students are motivated by results, that is, many choose a degree programme more for what it can give them than because of an innate interest in the subject matter. Our conjecture is that one will have more success in helping the students if you first understand their motivation and then tap into this.

Conclusions: (1) We decided to use an incentive driven approach to learning. This is described in more detail in section 3. (2) Good resources should enthuse and enable learning.

2.3 Staffing issues

A major issue with teaching development is the associated staff workload. Academic staff are employed primarily to do research and get little credit or opportunities for promotion based on teaching. As such staff need motivating to improve the teaching environment for the students where this would involve substantial time and/or effort.

Here the national landscape is changing and with the increasing significance of national teaching awards [13] and similar minor internal incentive schemes, more staff are being encouraged to put substantial time into teaching development. In Sheffield, there is a small pot of money that staff can apply for, to get assistance for innovative teaching developments and this serves both as an encouragement but also reduces the workload implications on the individual. The project evaluated in this paper was achieved with the support of an internal grant which was used to employ a teaching assistant to do some of the mundane and repetitive tasks required and also to buy an expert's time for coding a few trial animations (produced in Macromedia Flash software [14]).

A significant factor for staff is the workload implications of providing regular quality feedback to students. As a consequence, students often receive relatively little feedback. The two main factors being:

1. The numbers of students combined with the lack of staff time means that turn around times are too slow to be effective.
2. Unless there is course credit (e.g. marks) associated, students rarely attempt tutorial sheets in good time. Also, they rarely seek comment on their proposed solutions.

So a major goal of this project was to find a mechanism for giving the students regular and targeted feedback (i.e. formative feedback) on their performance without requiring the lecturer to do long amounts of marking.

Conclusion: We decided to make use of the automated assessment feature within WebCT [10]. This enables immediate formative feedback and is specific to the student.

3 Resources and evaluation

It is emphasised here that a fundamental, and often overlooked, part of any learning development is the associated evaluation. Where possible this evaluation should be independent of the lecturer. The resources discussed here were developed on the WebCT learning environment [10] as that has been adopted as the internal standard at Sheffield. This section gives a brief overview of the resources developed and then a summary of two years (2002/03 and 2004/04) evaluation by the students of these resources. The summary of the first year’s evaluation (2002/03) has already been reported [5].

3.1 Primary resources developed and pedagogical reasoning

The basic premise taken is that scientific topics are often learnt through repetition over a reasonable (not too short) time span. One project of note that has used this extensively is the mathematics learning support centre [7] at Loughborough University. Here the students are provided

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1 Some would argue that this is good as it forces students to take responsibility for and manage their own learning i.e. student-centred learning which is an important part of their education.
2 Attendance at tutorial classes is often very low.
with large databases of questions from which they can do self assessment. The key factor is that the databases are accessed and assessed via the web and hence the student can use them anytime, almost anywhere, and they can do it by themselves. It is straightforward to incorporate ideal answers for each question.

Such a database satisfies three of the pedagogical requirements:

1. Students have the facility to self test and hence receive immediate feedback on their progress.
2. For those who use the questions database, there is the opportunity to learn by repetition i.e. trying many similar questions.
3. Students can be given an incentive to participate by linking credit directly to performance. Participation ensures points 1 and 2 occur; resulting in learning.

For the systems modelling module, three questions databases were developed on the WebCT site to go with different components (or weeks) of the course.

3.2 Secondary resources developed and pedagogical reasoning

These were developed within WebCT and are summarised briefly:

Web-based discussions board: Enables students easy and rapid access to the lecturer (and each other), assuming they check and respond regularly. Hence, improves quality and quantity of feedback. Also helps avoid the need to answer the same question repeatedly. Reoccurring issues can be brought to subsequent lectures for clarification.

Date released material: Such things as tutorial answers, past exam papers/solutions and extra parts from the lectures can be made available after a certain date. Gives students an incentive to log on regularly (and hence to keep on working) and makes it easier for the lecturer to deliver additional material to everyone.

Audio and video: It is recognised (see [12]) that humans can learn better from audio and video as opposed to paper. Web-based delivery is an ideal mechanism for facilitating this. The down side is the high cost (time and money) of production. For this module some Flash animations, with audio and subtitle commentaries, were developed and made available on the WebCT site. The animations lead the students step-by-step through electrical circuit modelling.

Coursework submission: Allowing web-based submission is more convenient for the students and reduces workload on the secretariat. Also WebCT automatically generates a file of submission times in case of any disputes.

Computer code and files: Easy to manage the WebCT environment to make soft copy of documents or computer code available to all students. Ease of access is popular with students.

3.3 Student motivation

The most important factor of all is to ensure that the students use the resources. Unfortunately such a task requires students to be conscientious and to work regularly which few will do by choice in the first year. Our conjecture, discussed further in the next section, is that students often need incentives beyond learning as an end in itself. The most obvious motivation is a qualification or in the case of a single module, the opportunity to acquire marks towards passing the module [9].

The solution we adopted to this is the make the self assessment tests part of the module assessment, so that students had a strong incentive to use them. In summary coursework tests were constructed from the identical questions database used for the self assessment tests but the course works were only available in pre-specified weeks. To reduce cheating, every student had a different random selection of questions from the database. The desired paradigm is that students used the self assessments to practise and hence learnt through repetition and then, when confident, took the coursework test itself.

3.4 Staff workload and student monitoring

Overall staff work load is not reduced by adopting a greater use of web-based support because in a properly blended approach, the lecturer is not only producing the good web resources but also using conventional lectures in support of these. However, once the web resources have been developed, the maintenance of these and the need to check the discussions board regularly is a relatively small task compared to the routine notes and module update required each year. Moreover, if the students seem more contented and use the discussions effectively, there is less interruption of the lecturer at other times.

However, an additional advantage of using web-based assessment (or other resources) is that WebCT learning environments will track student usage. This information is automatically collated and hence can be correlated immediately (as course works are marked automatically) with coursework performance. This information can be fed to personal tutors who (assuming they meet regularly in semester 1 as they do in Sheffield) can arrange to see any struggling student early enough to help. This latter form of indirect feedback, via the tutor, is invaluable for identifying and encouraging weak students quite early in the semester and should improve progression rates.

3.5 Evaluation

This section gives a brief summary of the evaluation [5,11] of the resources undertaken in 2002/03 and 2004/04.
Courseworks. Over the two years the completion rate of the courseworks was approximately 95% with an average score around 70-80%.

Self assessments. The uptake of the self assessments (2003/04) was:
- Everyone did self assessment 1, 90% doing more than once.
- Nearly all did self assessment 2, 75% doing more than once.
- Nearly all did self assessment 3, 70% doing more than once.

Usage of other resources %
Based on student questionnaires, the following data was obtained (see table 3.1) on the percentage use of the web-based resources.

<table>
<thead>
<tr>
<th>Resource</th>
<th>0 times</th>
<th>≥ 5 times</th>
<th>≥ 10 times</th>
<th>&gt; 10 times</th>
<th>No reply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture notes</td>
<td>32</td>
<td>43</td>
<td>15</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Empty boxes²</td>
<td>55</td>
<td>24</td>
<td>10</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>Tutorial sheets</td>
<td>22</td>
<td>45</td>
<td>15</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>Tutorial answer</td>
<td>17</td>
<td>39</td>
<td>21</td>
<td>18</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 3.1 Usage of other resources %

The “empty boxes” are the gaps in the lecture notes. These are time-released to the students via the WebCT site after the lecture has taken place.

Usage of Discussion board % (based on questionnaires)
- Not at all: 25%
- To read other persons entries: 55%
- To ask questions: 20%

The WebCT learning environment
Approximately a third of students encountered access problems at some time, often due to remote connection issues. However, over 95% stated that access was good.

Summary [11]
The students appreciated that the WebCT site:
(i) Provided familiarity with and opportunity to practice coursework assessment questions.
(ii) Supported understanding by the provision of lecture notes and additional material, enabling freedom of access.
(iii) Immediate feedback and access to a peer-learning environment.
(iv) Access 24/7.
(v) Allowed the opportunity to identify weaknesses in understanding and to address them thereby improving learning (and obviously marks).

The overall comment was that they liked the style of presentation of the module and did not suggest any changes.

Criticisms were mostly minor. For example, irritations due to remote connection failures and a few students desired a more challenging, perhaps hand written, coursework. Also, unsurprisingly they also requested more, of everything.

4 Student behaviour
As mentioned earlier, if one desires to engage students actively in the learning process, it is necessary first to tap into what motivates them. In this section, we interpret the evaluation data with the aim of understanding which resources the students used and why? In order to give us some evidence to back up any conclusions, we used a semester 2 computer-based class to get a third (29 students from 70) of the 2003/04 cohort to fill in a WebCT survey. The survey asked questions relating to the resources they used, why and whether they were helpful.

4.1 Survey results (summary)
For the quantitative data obtained from the online WebCT survey, see tables 4.1-4.3.

In terms of the qualitative comments, the students really liked the self assessment/coursework paradigm as it gave them confidence in their own learning and the power to take the coursework when they felt ready. However, although they felt the courseworks helped with learning basic topics, the limitations of automated computer-based assessment meant that the style of questions was far simpler than those encountered in a written exam. Hence, they did not get sufficient feedback on their mathematical ‘working’.

<table>
<thead>
<tr>
<th>Resource</th>
<th>Self assess</th>
<th>Past exams</th>
<th>Animation</th>
<th>Empty boxes</th>
<th>Tutorial answers</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage</td>
<td>97</td>
<td>88</td>
<td>50</td>
<td>50</td>
<td>55</td>
<td>25</td>
</tr>
</tbody>
</table>

Table 4.1. Usage of resources (%)

<table>
<thead>
<tr>
<th>Resource</th>
<th>Credit</th>
<th>Credit and interest</th>
<th>Interest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage</td>
<td>57</td>
<td>32</td>
<td>25</td>
</tr>
</tbody>
</table>

Table 4.2. Motivation for usage (%)

<table>
<thead>
<tr>
<th>Resource</th>
<th>Agree</th>
<th>Unsure</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage</td>
<td>58</td>
<td>31</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 4.3. Was repetition useful for learning (%)

4.2 Understanding student behaviour
The survey results above reinforced what we had already begun to suspect. Here are the observations from this study:
1. Many students do not have the basic interest to surf a small web site to look at what resources are available, let alone take the time to use them.
2. They are motivated mainly by gaining marks and predominantly use resources that target this directly.
3. Resources, even excellent ones, that only indirectly help the students acquire marks were underused.

Some simple examples of this:
1. The animations gave a talk through (pseudo lecture) of circuit diagram modelling and were accessed

³ Due to this being a 1st year course, the registered numbers usually exceeds the number making a conscientious attempt.
⁴ Gaps in the handouts usually completed in lectures.
through an icon (one of only 6) on the home page of the site. Nevertheless 50% of students never even looked at them. Those who did said they were invaluable.

2. The discussions board had relatively few contributors. We do not believe this means the students had no queries or confusion as the overall module assessment average is around 60%.

3. Nearly everyone did all 3 courseworks and the associated self-assessments to help them prepare.

4. Many did not access the tutorial answers but far more accessed the past exams.

As a lecturer, these observations are somewhat frustrating as it can take considerable time to create resources which you believe are good pedagogical tools for learning a given topic. However, the bigger challenge is getting students to engage with them and our experience seems to be that the majority will engage only if they get credit for doing so.

5 Conclusions

In this paper we have summarised a teaching and learning project from start to finish, including a relatively comprehensive evaluation. Our second observation is perhaps expected and relatively well known, although this case study adds to the body of evidence for this. That is, students (especially weak ones) tend to do better and work more consistently where there is a substantial coursework element in a module. Also, they are more encouraged when they get fast feedback on their submissions.

From our first and third observations, we did not fully expect at the project outset. An initial aim was to improve the learning experience which we decided to do through creating web-based resources which therefore offer something different and give value added. Considerable expense and time was spent creating the animations. However, 50% of students did not even look at them! The conclusion seems to be that students are highly motivated to do only what gives credit. Resources that support learning but carry no direct credit are under utilised.

Our next task is to look at this latter conclusion in more detail. As a University, the aim is to help students into good learning practises, by providing excellent teaching resources to ultimately help them to learn. The main challenge seems to be how to create useful resources with which the students will fully engage and hence learn more effectively.

References