Revitalizing First Year Electrical Engineering

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Abstract: *Creating a first year engineering unit which is stimulating, exciting, but still covers the 'raw' material required can be a difficult task. The undergraduate engineering course at Monash University includes a 'common' first year, in which students have a taste of many engineering disciplines before choosing to complete their degree in a particular field. This paper describes and assesses the methods used to re-engage with students and revitalize the unit: better use of electronic resources, regular online student assessment during semester and new laboratory experiments.*

1. Introduction

This paper presents the transformation of ENG1030: Electrical Systems, to better meet students' expectations and improve the quality of teaching. Designing a first year unit that meets the huge range of requirements is hard: Electrical engineering has in the past been considered a 'difficult' unit, and students enter the course with a range of different backgrounds. Some students will choose to pursue further studies in this field, or it may serve as a 'terminal' unit for other students who choose to study other engineering disciplines. The unit also needs to serve as something of 'sales pitch' for studies in electrical engineering: some students will be undecided on their choice of engineering specialization, and the quality of the first year unit has a direct bearing on their perception of the field.

ENG1030 had been taught in a similar manner for many years at Monash University, with 'traditional' content delivery and assessment. As part of this process of renewal, efforts were made to modernise the unit in many aspects, including creating modern and relevant laboratory experiments, embracing online teaching technologies, changing assessment to provide regular testing of students during semester, and an updating other resources to give a consistent look and re-useable high quality content in future semesters.

2. Background

There is a wealth of literature detailing the design of effective first year units and courses. The idea of Problem Based Learning (Norman & Schmidt, 1992) has been used in many courses (Steedman, Smith, Keleher, & Martin, 2006) (Brodie & Porter, 2008) (Mantri, Dutt, Gupta, & Chitkara, 2008) as an effective way to help students come to terms with unfamiliar ideas, by allowing them to explore the concepts in a collaborative, interactive environment. (Smaill, Godfrey, & Rowe, 2007) found that students entering an first year electrical engineering course can have vastly different understandings of basic physics material.

Additionally, efforts have been made to integrate technology into classrooms and course delivery: online assessments (Deeks, 1999), effective use of online content management systems (Yench, Crosky, Wilk, & Allen, 2008) and as an aid in managing units with large enrolments (Williams & Sher, 2007). (Hadgraft, 2007) emphasises the need for more effective integration of online assessment in teaching and a better understanding of what online resources are available.

(Pendergrass, Laoulache, Dowd, & Kowalczyk, 1998) state that the failure of traditional content delivery methodologies for large units impacts directly on the students' perception of the unit, and suggest that encouraging student participation is key to providing a better experience. (Shuman, Heer, & Fiez, 2008) give a review of their approach to re-developing a lab sequence to be more hands-on and interactive. Other related work on exploring and developing the role of first year includes the workshop "Reforming the First Year Engineering Experience" (University of Melbourne, Australia) in August 2009.

3. Planning Change

ENG1030 covers a 'standard' range of first year electrical and electronic engineering material; basic circuit theory and analysis, operational amplifiers, digital logic systems, AC circuit analysis and some introductory electro-magnetic theory. Overall, the consensus was that the material taught in the unit was essentially correct, and that the problems lay in engaging with students and conveying a sense of excitement, as well as a 'big picture' view of where the ideas fit into modern engineering. The teaching team consisted of four academics with different backgrounds and industry experience, which could be drawn upon in the development of high quality, up-to-date content. Monash University is a multi-campus institution, and this unit is taught concurrently at the Clayton campus in Australia, and the Sunway campus in Malaysia.

Some constraints restricted a complete move away from traditional teaching techniques. Due to the size of the class (200 – 300 students), and the possibility of changes in staff in future, the standard 'lecture/lab/tutorial' model would be used to ensure the transition would be as simple as possible. However, this model would be augmented in two important areas:

1) A complete re-write of the laboratory series, in an effort to convey to students the potential of modern electronics, as well as an ability to use modern test equipment.
2) Regular, problem based online assessment. By replacing the two major tests during semester with regular online assessment, students are met with a requirement to stay up to date throughout the whole semester, instead of attempting to 'cram' at the end.

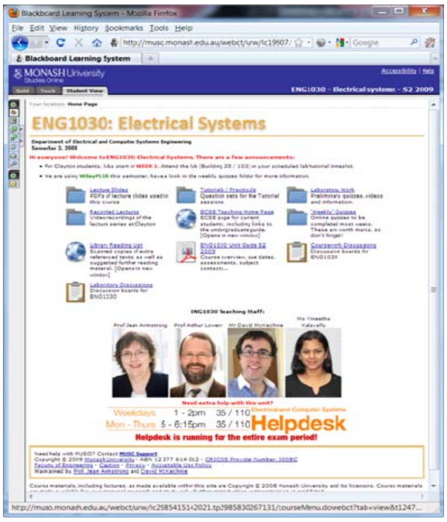

Figure 1 – New Blackboard website design

Improvements were made in many other areas: changes to the unit website to make it friendlier and more organized (Figure 1); the introduction of 'team teaching' with two lecturers in attendance at most lectures; the adoption of tablet-pc based lecturing in a similar fashion to (Hulls, 2005) but with the addition of video recording; and adoption of online discussion boards and online announcements as the primary communications channels between staff and students.

4. Laboratory Series

A new set of experiments were developed, with the key feature of a printed, bound lab book with experimental instructions and spaces for students to answer questions or make notes as appropriate. Having these notes avoids a problem in undergraduate lab work of insufficient recording of results and students' general inability to keep lab notes organized. Providing soft copies of lab notes has also proved ineffective in the past, as students tend to avoid printing the notes and instead attempt to flick between windows on lab PCs.

Figure 2 – Undergraduate teaching labs

The Monash Electrical Engineering department has recently renovated their undergraduate teaching labs (Figure 2), so the new experiments aimed to make maximum use of these new student facilities. An emphasis was placed on 'getting the circuit to work first', and analyzing it second, with experiments designed to be as relevant and engaging as possible.

The lab series consists of 5 experiments:

1) **An introductory experiment.** This experiment is designed to serve as an introduction to equipment that will be unfamiliar for most students. The emphasis is on 'light and sound': simple circuits that *do things*. Students must prototype simple circuits with LEDs and a small piezo (a highly efficient speaker, as used in digital watches and car alarms), use the arbitrary waveform generator, and the digital storage oscilloscope.
2) **Operational Amplifiers.** Students must construct a basic op-amp circuit, but with a twist: it is used to amplify audio from their mp3 player (or department computers), instead of the traditional sine wave. This builds on the work they have already done characterizing the piezo sounder, and again provides a 'real' application for material covered in lectures and tutorials.
3) **Logic and Switch Debouncing.** Students are introduced to the concept of switch bounce, and why it is so important to understand. The most abstract of the labs, students must construct two different de-bounce circuits to see a practical application of basic logic circuits.
4) **Using FPGAs.** Students are given a framework to implement a seven-segment HEX display using switches as inputs and LEDs as outputs. They undertake the task in two ways: firstly using schematic capture logic design, then using simple snippets of *Verilog* programming language. Students grasp the concepts very quickly, which is notable give the absence of any formal lectures on FPGA design.
5) **Laboratory Test.** The final assessment for the lab series consists of a short, simple laboratory test, worth half the available marks for lab assessment. The goals of this test were twofold: firstly, to ensure students leave the course with a basic competence in the use of the equipment (AWG, DSO), and secondly, to penalize 'passenger' students who often manage to obtain reasonable marks during lab sessions based on the work of their lab-partner. The lab test was a simple problem solving exercise, like "construct a two stage op-amp circuit with an overall gain of -20, with very high input impedance." Students were given 45 minutes to design, build and test their solution, before being marked based on practical skills, and documentation.

Students were marked on the spot by lab demonstrators, providing instant feedback on their work. An emphasis was placed on preparation: two thirds of the mark each week was awarded for proper preparation for the lab, with the final third being awarded for practical work done.

Preliminary work for the laboratory series was set as an on online test due 10 pm the night before the lab. Questions are selected at random from a larger bank of questions for each lab: this eliminates copying and the need for demonstrators to spend time marking work. These quizzes also included a random lab safety question, in an effort to raise the profile of OH & S requirements for students in lab sessions.

Short video introductions to each lab (~5 minutes) were recorded using a departmental webcam. These videos highlight difficulties students may face when running the experiments, and provide tips on how to avoid them. In particular, specific attention is paid to the use of equipment (arbitrary waveform generator, digital storage oscilloscope) that students might otherwise struggle to use effectively.

5. Online Tools

Online Testing

Although Blackboard Learning System has been in use at Monash since 2001 (Weaver, Nair, & Spratt, 2005), this unit had not been making extensive use of the available features. In new arrangements, online tests were created to run every other week. These tests were worth 1% each (7% total) of the students' final grade: it is known (Ramsden, 2003) that most students will "Study what they think will be assessed". Care was taken with the setting of these tests to ensure they were tightly integrated with the content discussed in lectures and the textbook, in the hope that they would serve as a focus for students' ongoing studies.

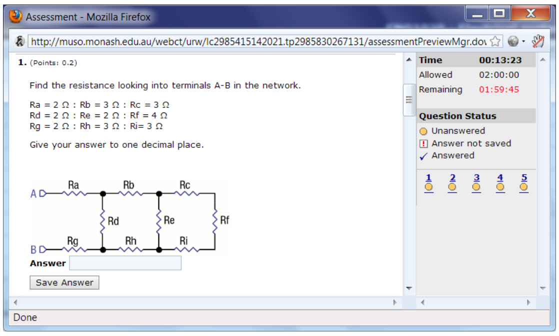

Figure 3 – A typical online quiz problem

Each test was set to allow two attempts, taking the best mark as final. Each attempt would present the same questions, but change the values of the numbers used in the problem. Students would print out or otherwise copy down the questions earlier in the week (Figure 3), then use their second attempt closer to the due date. This proved an excellent mechanism for fostering group work: most students worked together to come up with generic solutions for the problems, which they could then apply to the specific problem presented on their second attempt.

WileyPLUS

The online tests set for assessment in this unit were modeled on those provided with the prescribed textbook: "Basic Engineering Circuit Analysis 9th Ed", *Irwin/Nelms*, *Wiley*. WileyPLUS is an online quiz system very similar to that described above, but with a vast array of questions ready to go, provided by the book publisher. The questions on WileyPLUS were set as 'practice' problems, with unlimited attempts, and extra features, like links into the appropriate material in the textbook. WileyPLUS also gives instructors detailed solutions to end-of-chapter problems as well as access to all source images from the textbook: this streamlined the creation of assessed tests significantly.

Discussion boards

The online discussion boards for the unit became the primary point of contact for students enrolled in the unit. Although discussion boards had been used previously, they had never had the success seen in 2009. During semester, the boards saw 579 posts, compared to 124 and 380 in Semesters 1 and 2 of 2008 respectively. A real sense of community was built around the message boards: it was interesting to notice several threads deviating off topic, with a staff member even being challenged to a game of *Starcraft* (an online computer game) by a student!

Teaching staff made an effort to post replies to emails and student queries via the discussion boards, rather than responding individually. By posting to the boards, the information was made accessible to all enrolled students. Although a core group of around 50 students was responsible for most of the posts, almost all students browsed the discussion boards and read more than 20 posts during the semester, and more than half the class read more than 200 posts.

6. Outcomes

The primary resource for assessing the effectiveness of the changes made is the unit evaluation survey run by the Monash Centre for Higher Education Quality (Centre for Higher Education Quality, 2008). The survey is voluntary for students to complete, and comprises the questions below as an online form. Students are asked to rank each question from 'Strongly agree (5)' to 'Strongly disagree (0)' with a score of 3 being Neutral. In 2009 the survey achieved a response rate of 61%, with 154 questionnaires completed. Although ratings like these are subjective, they give a good indication of the performance of a unit.

Survey Results

Figure 5 shows the mean results for ENG1030 placed against the average score (weighted by the number of questionnaires completed) for all first year engineering units. The error bars on the average results indicate the highest and lowest score received by any unit in first year engineering for semester 1 2009.

The unit scored above average on every question. For several questions ENG1030 scored best or equal best in first year. Q5, which is considered the 'most important' question, was a standout result, as were Q2 and 3.

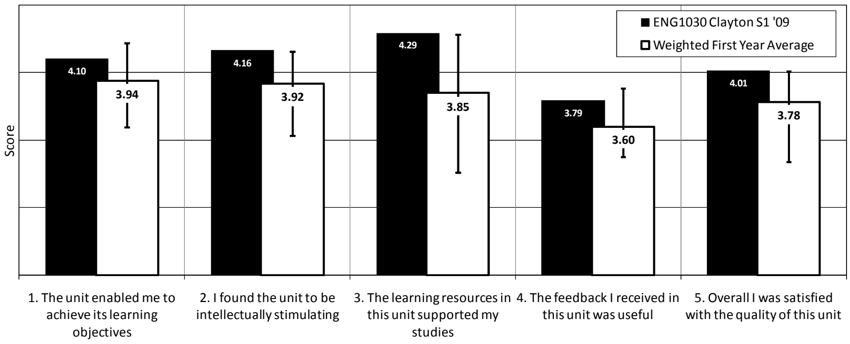

Figure 5 – CHEQ Evaluation Results Semester 1 2009 (Engineering)

It is clear that students value the online resources and well-organized web portal, as well as the quality and consistency of materials presented (Q3). Engineering specific questions (not shown here) also showed excellent performance, with exceptional responses (best in first year engineering) on questions asking about the students' opinion on the quality of the tutorials sessions and laboratories.

This data supports anecdotal conversations had with students during the semester. In tutorials and after lectures, comments were made regarding the quality of the online materials, and unit in general:

The quizzes in this unit work much better than those in (Unit X)
How could electronics be boring?
I was thinking about doing Mechanical (engineering) but now I'm considering Electrical too
Electrical (engineering) is my favourite unit at the moment

The reference to quizzes in another unit was interesting: it is understood that some units utilize online testing in a similar fashion, but can be moderately prone to errors in marking which detracts from their usefulness. The care taken with creation of online assessments in this unit has contributed to their success, and students' willingness to study for them.

International Success

Ensuring parity education across campuses can be difficult. The online resources proved to be an excellent example of how web-based technology can be used to ensure equivalence of standards across the two campuses. The students' performance in the final exam on both campuses was the most tightly coupled in first year engineering and proof of a successful international teaching collaboration. A difference of less than 2% was observed in the relative mark breakdowns (High Distinction, Distinction etc), as well as a low failure rate at both campuses.

7. Conclusion

The changes made in ENG1030 in 2009 have proved a resounding success, transforming it into one of highest performing units in first year engineering at Monash University. The combination of quality online resources, relevant and modernized laboratory sessions and continual student assessment has provoked student interest in the field of electrical engineering.

Moving large portions of the assessment to an online system yielded a consistency in assessment that was appreciated by students and will make the unit simpler to teach and administrate in future. Providing real-world applications in simple laboratory experiments gave students an opportunity to consider what they were learning in the context of technology they already understood.

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