STRATEGIES FOR INCREASING UNDERGRADUATE POWER ELECTRONIC COURSE ENROLMENTS

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Abstract

Over the last decade student enrolments in electrical power engineering subjects at the University of Canterbury have been falling. This paper discusses changes designed to stimulate interest in power electronics. One of the changes that has been introduced is the use of practical assignments to stimulate interest. In the Year 4 power electronics course the practical assignment is to design and build a DC-DC converter for use in a mini solar car race. A number of other strategies, such as the early introduction of power electronics, team teaching, industry relevant lectures and fields trips have also helped increase the number of students enrolling in power electronics and other power engineering courses at the University of Canterbury.

1 INTRODUCTION

Since 1994 there has been a reduction in the number of students taking optional electrical engineering courses in power systems, electrical machines and power electronics at the University of Canterbury, New Zealand. This paper presents a number of steps taken to increase enrolment numbers and concentrates on how practical assignments are used to stimulate student interest in power electronics.

If electrical engineering education is looked at from an international perspective then there are many different stages in an undergraduate degree programme in which electrical engineering subject areas are introduced. Based on a 1996 survey of power electronic and electrical machine courses in North American and Australasian Universities it was found that these courses are taught with different levels of detail at the undergraduate and postgraduate levels [1]. It was found in North America that electrical machines is usually a required part of the undergraduate program, but that power electronics is optional and in some cases only offered at a postgraduate level. This is in contrast to Australasia where power electronics often forms part of the required course content at the undergraduate level. These two aspects, the dominance of traditional undergraduate electrical machines courses in North America and the dominance of the general undergraduate power electronics course in Australasia, provide a basis to develop a strategy to increase enrolments. 93% of universities in Australasia offer at least one undergraduate power electronics course, whereas the equivalent course is offered by only 39% of North American universities. Power electronics is perhaps the most recent power engineering discipline and it pervades all modern applications and advances in power systems and electrical machines. Student perceptions are that power electronics is a new and exciting technology, as opposed to traditional electrical machines and power systems that are both considered well established with little scope for innovation. By making part of the assessment of the power electronics course contain a practical assignment based on a solar car race it was aimed to stimulate students' interest in power engineering subjects. Other power engineering courses have also included practical assignments with a great deal of success. This paper discusses in detail a major Year 4 power electronics practical assignment and briefly mentions other strategies implemented to increase enrolments.

2 COURSE STRUCTURE

The undergraduate electrical and electronic engineering course structure at the University of Canterbury is a four year program with a common Intermediate or first year for all engineering disciplines, followed by three professional (or specialist) years. All Year 2 students study three core electrical and electronic engineering subjects; Circuits and Systems, Electronics and Electrotechnology. In addition they undertake courses in Mathematics, Engineering Design and Mechanics. In Years 3 and 4 the students take one compulsory subject, a Design course in Year 3 and an individual honours project in Year 4. Other than that the students are free to select 9 subject options in Year 3 and 5 options in Year 4. Allowing students free choice in their subjects has been in place since 1990. Prior to this students were only permitted a limited choice in their Year 4 of study.

The use of subject options result in students selecting subjects that they are most interested in or ones that they perceive will get them jobs. Today, the courses that attract most interest and the largest student numbers are in the areas of communications, signal processing and computer engineering. At the University of Canterbury students are not streamed according to their major interest. There is no set of compulsory power engineering courses and therefore to increase enrolments in these courses the course content and presentation must be changed to attract students. To do this the course content in the three professional years needs to show that the electrical power engineering subjects have modern content even though some of them have been around for 100 years. The students need to also see that industry requires graduates with the traditional power engineering skills together with modern skills such as computing.

3 STUDENT NUMBERS IN ELECTRICAL ENGINEERING COURSES

The percentage of Year 3 students undertaking electrical power engineering subjects compared to the total number of students enrolled in that year has been steadily falling since 1991 as shown in Figure 1. The number of Year 3 students reached a minimum in 1997. It is important to note that the Year 3 course of each electrical power subject (power electronics, power systems and electrical machines) is a prerequisite for the corresponding Year 4 course. Therefore the number of Year 4 students reached a minimum in 1998. Since 1998 the student numbers in Year 3 undertaking electrical power subjects has started to rise again. This is due to a number of strategies undertaken to increase the student enrolments.

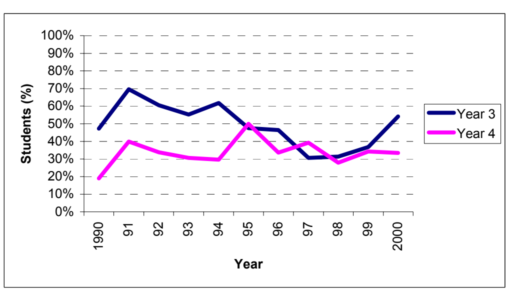

Figure 1: Percentage of Students in Year 3 and 4 Electrical Power Subjects

Year 3 and 4 power electronic courses have always had a large percentage of the undergraduate students taking these courses as shown in Figure 2. At the Year 3 level there had been a downward trend of student numbers from 1991 to 1997. Since the Year 3 numbers were decreasing this means that a lower number of students progress into Year 4 power electronics. In 1994 the emphasis of the course at this level was changed to be primarily applications based. To enhance the application emphasis, the course assessment contains a 25% practical team assignment. In this assignment the students have to design a switching converter to match a 10W solar panel to a DC permanent magnet motor which drives a model radio controlled vehicle. As part of the assessment, the students have a public race to determine the fastest vehicle.

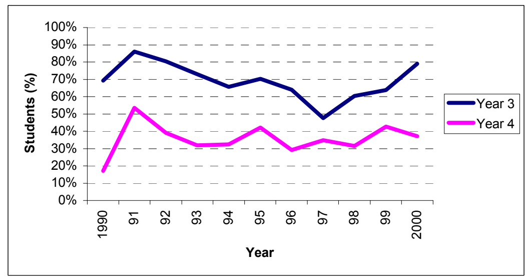

Figure 2: Percentage of Students taking Power Electronics

4 PRACTICAL ASSIGNMENT

To master power electronics, or in fact any subdiscipline within electrical engineering, a student should demonstrate a proficiency in [2]:

(a) factual knowledge;
(b) knowledge of engineering procedures;
(c) the ability to identify key concepts;
(d) the ability to acquire new knowledge;
(e) judgement to use incomplete / contradictory information.

Traditional western style university curricula address the first two items, but the remainder are either overlooked or addressed outside the classroom by a range of engineering activities. This is principally because assessment of these last three items is perhaps more difficult and time consuming and generally not afforded by conventional laboratories.

At the University of Canterbury, we have had an annual model solar car race since 1994. Students usually work in groups of two to ensure that they all experience some aspect of design, decision making and teamwork.

Students are required to design, build and demonstrate an electronic controller (dc-dc converter) to match the output from a 10W solar panel to a permanent magnet

DC motor. Each group is provided with a 10W solar panel mounted on an aluminium chassis along with the dc motor, a gearbox and a servo for steering the vehicle (Figure 3). The servo is remotely controlled via a handheld radio link and is the only on-board item which can be powered from an auxiliary battery source. Students are not allowed to alter any mechanical characteristics of the car and the problem can only be solved by designing and building electronics. The objective is to have the fastest car on race day and the vehicle must be able to start moving under its own power as soon as sunlight falls on the panel. To achieve this objective two key design tasks have to be optimised; maximum power must be collected by the solar panel and transferred to the dc-dc converter, which inturn must transfer the power to the motor as efficiently as possible. Each year these are the basic instructions given to the class, but just to keep everyone honest an additional new requirement is added each year. For example, one year the specification may call for the cars to be reversible and the next the class is told that diodes are not allowed and the designs must resort to synchronous rectification.

Figure 3: Solar Car Mechanical Construction.

The solution to the problem is essentially open-ended, average students achieve a good basic working design, while the better students have ample scope for improving efficiency of their converter or extracting that last bit of power from the solar panel. Even the weakest groups usually manage to get a design completed which will at least partially satisfy the conditions of the race.

A ASSESSMENT

This particular assignment nominally counts for 25% of the total course assessment. Three components make up this 25% assessment; a laboratory review worth 10%, an individual written report worth 15% and a group bonus mark of up to 5% awarded for the car's performance on race day. Thus there is the possibility of a student scoring 30% if they can manage to do extremely well in all aspects of the assessment. Typically this assignment runs over a six week period and at the conclusion of week five each group is subjected to a laboratory review of their progress. They meet with the lecturer in the laboratory, bringing with them their hardware, a copy of their circuit diagram and their design notes. From a list of previously published questions members of the group are asked to demonstrate their hardware and to answer questions about the performance of their hardware. Questions can be directed to each individual group member and even though a group mark is awarded for the laboratory review it is quickly obvious whether or not each individual understands what they are doing and the relative contributions of each group member can be readily assessed.

The emphasis on the assessment of the individual report is on documentation of the design process, their understanding of that process and finally the evaluation of their design. A number of design decisions have to be made on the basis of incomplete or non-existent information. For example the dc motors have been rewound and no details of their new characteristics are provided at the start of the assignment. Each group must make their own decisions on the information about the motor which they believe they need and devise a method of measurement. Manufacturer's data sheet for the 10W solar panel is provided, but as is often typical with engineering problems the data sheet does not provide the information which is required to solve the problem at hand. The bonus of up to 5% for the race (Figure 4) is allocated to each group on a very simple scale ranging from 1% if the car starts under its own power on race day to 5% if a 1st or 2nd placing is gained in the final race of the day.

Figure 4: Race Day

B SUMMARY

Gregson and Little [2] identify ten characteristics of a good contest:

(a) is safe;
(b) requires increasing factual and procedural knowledge;
(c) requires exercising engineering judgement;
(d) fosters creativity;
(e) incorporates significant course material;
(f) provides success commensurate with care in design;
(g) permits many strategies with levels of success;
(h) does not require significant infrastructure;
(i) is easy to understand with simple scoring;
(j) should be a spectacle.

We believe we have achieved all of these characteristics in this assignment and over the years student feedback has confirmed that they believe the time spent on the assignment has been well worthwhile. The race is a vital part of the success of this assignment, it is an important motivator and publicity tool. Year 2 and 3 students see power electronics as being as being challenging and a fun learning experience.

5 OTHER STRATEGIES

In addition to the practical assignment a number of further initiatives have been undertaken to stimulate interest in power electronics. These are the early introduction of power electronics to Year 2 students, the use of team teaching, providing relevant industry technology lectures and field trips. Each of these initiatives is now discussed.

A YEAR 2 POWER ELECTRONICS

A way to change student perceptions is to introduce to them modern electrical applications. At the University of Canterbury these ideas have been introduced into the compulsory Year 2 courses so that all students are exposed to them before selecting their subject options.

In the Year 2 Electronics course a block of lectures on power semiconductor devices was introduced in 1989. The idea behind this was to expose the students to the use of power devices and some applications. In 1997 these lectures were integrated throughout the course rather than being taught as a separate block of lectures. This is because power electronics is the use of electronics in higher voltage and/or current circuits. By integrating the lectures, power devices are treated the same as small signal electronic devices and the students see no differences in the usefulness of these devices. In addition, a single lecture is given on some of the interesting applications of power electronics, such as electric vehicles and switching power supplies. In showing these applications, products produced by New Zealand industry are discussed to show that this technology is relevant and that there are local companies producing power electronic products. From Figure 2 it can be seen that these changes have resulted in an increasing number of students undertaking power electronics in Year 3 from 49% in 1997 to 78% in 2000.

B TEAM TEACHING

Since 1997 a team teaching strategy in Year 3 power electronics has also been implemented. This strategy gives balance to the way in which material is presented and the students are exposed to a range of topics without bias. Currently the course is taught 50% by a specialist in power system applications and 50% by a specialist in industrial applications. The material up to 1997 was also presented as a course of core material with little recourse to applications of the technology. Students found this approach dull and uninteresting, so in 1997 we have made a more conscious effort to discuss applications and to point to where the technology leads.

C RELEVANT INDUSTRY TECHNOLOGY LECTURES

Traditionally electrical machines has been taught as a specialist Year 3 and 4 course and was based on the design and analysis of electric motors and transformers. To expand the subject area and to add a modern emphasis to this course, a block of lectures on motor drives was added. This was initially introduced at the Year 4 level in 1998. In this lecture block AC motor control principles, which were previously part of the power electronics course, are discussed. Since then a block of lectures has been introduced into Year 3 on the control of DC machines and in 1999 for the first time 6 lectures out of 48 were devoted to the general area of power electronics and motor control at the compulsory Year 2 Electrotechnology course. These included two lectures on permanent magnet DC motor control using a chopper, three lectures on how to control AC induction motors, and a final lecture on an electric vehicle application of an AC motor controller. The lecturer who gives the lectures in this course is the same lecturer as in the Year 2 Electronics course. By using the same lecturer the students then start to see the over lap between modern electronics, computer control systems, power electronics, magnetics and motors.

In the Year 4 courses a number of industrial people are invited to give lectures to the students on topics such as high frequency transformer design and soft starting of AC induction motors. This gives the students the opportunity to learn about the real problems that confront engineers and the techniques they use to solve them.

D FIELD TRIPS

The department runs a voluntary 4-day field trip in which 40 students are taken to an aluminium smelter, an underground power station, a HVDC converter terminal and a large earth-dam power station. In the past this trip was available only to Year 3 students and in particular the students taking the power systems course. In 1998 for the first time the power systems trip was targeted to the Year 2 students. In the last two years since offering this trip to Year 2 students there has been an increase in the number of students undertaking power courses at Year 3. The field trip allows the students to speak to electrical power engineers and find out what they really do. It also gives the students the opportunity to assess the relevance of the courses that they are planning to choose for the following year.

6 CONCLUSIONS

By making power engineering courses seem relevant to the modern world and by showing the students that there is a demand for these kind of engineers has helped increase the overall number of students choosing electrical power engineering subjects as part of their degree program. This is in part due to the use of a practical assignment in power electronics. The students learn a great deal from this assignment and by holding a public race then the idea that these are useful and exciting subjects is emphasised. In addition the course content in Years 3 and 4 has been redeveloped to provide a balance of core material and applications. Team teaching is now employed in all the electrical power engineering courses with specialists teaching their topics of interest. At this stage it is still too early to say if these changes will produce a continuing long term increase in the number of students taking electrical power engineering subjects. However if the initial trends continue then there is a positive future for power engineering at the University of Canterbury and the profession in general.

7 REFERENCES

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[2] Gregson P.H. & Little T.A., "Using Contests to Teach Design to EE Juniors", IEEE Trans. on Education, vol. 42, no. 3, August 1999: 229-32.