Integrating the World Wide Web into an Introductory Course in Mechanical Engineering

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Engineering I is a new course aimed at introducing students to the real world of engineering, show how engineers set about doing their work and how they analyse and solve problems. Student involvement, active learning, rapid feedback, and high expectations are key ingredients of the course. Described is the course’s philosophy, and how it’s structured and presented in the form of self-contained modules. These modules are available on the Departments website for use by anyone in the development of their own curricula. In return it is hoped that there will be feedback on how they can be improved.

Introduction

It has been widely reported, both locally and internationally, that interest in engineering has been declining. The paradox is that the technological challenges facing the profession have never been more challenging or exciting. It has become clear during the past decade that a thorough re-evaluation of the Department’s curriculum is necessary. The reasons for this include the fact that attrition rates remain high even though many of the students being admitted into engineering have excellent credentials. This situation has been both puzzling and distressing. Surveys of students are revealing what has always been suspected. They find engineering degree courses boring, in particular the early formative years, with a jammed packed and overloaded curriculum as compared to other disciplines.

The perception of industrialists, on the other hand, is that engineering graduates are not meeting the needs of today. They see a need for broad-based, flexible graduates who
can think and solve problems. They acknowledge and support the growing importance of specialisation in particular fields. However, they see this happening through continuing education programmes rather than by cramming more into an already jammed curriculum.

Research into student learning clearly indicates that the effectiveness of university education could be significantly improved, despite the trend to larger classes due to constrained resources [1]. Engineers of old who grew up before computers and television were tinkerers with hobbies like building Meccano models, crystal radios, model aeroplanes and boats, or keeping an old car in running order. These tinkerers developed a common sense feel for engineering. They learned about basic hardware and tools and how to use them and from this, developed a visual way of thinking. With this background, an engineering education was the next logical step, adding technical depth and theoretical understanding to the underlying principles they already had a feel for. The reason these people went into engineering was because they liked working with their hands and on machines.

Today’s engineering students show a very different profile. While there are still some students who come from families where there are engineering connections, most have had little or no exposure to engineering and only a few have indulged in any form of technical hobby. Many have chosen to do engineering because they did well in mathematics and science and were told by guidance councillors they would do well in engineering. Some chose to do engineering because they were offered bursaries to study engineering on the strength of good Matriculation results having previously given a career in engineering very little thought. Without previous physical experience or mental pictures of how things work, many students have great difficulty with the theoretical engineering education being provided. All along they are told that the fundamental courses in mathematics, physics, and chemistry are important. They are expected to learn the material in good faith with the expectation that they will need it later. However, without some physical experience to give meaning and context to the material, most of it is quickly forgotten or rarely applied because they do not have the confidence to make use of it.

In re-examining the framework of the Departments 1st Year curriculum, direction was determined both from the authoritative findings of several studies that documented the
need for change, and staff members own consensus of the characteristics and capabilities that graduates will need to succeed in engineering in the future. The more important of these studies were the discussion documents prepared by John Sparkes [2] for the Engineering Professors’ Conference titled *The Future Pattern of 1st Degree Courses in Engineering*, Alexander Astin’s [3] paper titled *Involvement the Cornerstone of Excellence*, Mac van Valkenburg’s [4] paper titled *Unjamming Our Curriculum*, and the Engineering Coalition of Schools for Education and Leadership Programme, ECSEL [5], a coalition of engineering schools in the USA funded by the National Science Foundation aimed at renewing undergraduate engineering education and making it more attractive to a broader spectrum of youth.

From these and others, the following revised curriculum was decided on. Full courses in Physics, Mathematics, and Engineering I and half courses in Chemistry, Applied Mathematics, and Engineering Drawing. The main changes being the addition of a new full course to introduce students to the engineering discipline of their choice, and some unjamming of the courses by focusing on content and reducing this to the essentials required for engineers rather than scientists.

**Objectives of the Course**

In the firm belief that "Theory without practice is sterile and that practice without theory is blind" it was decided that this new course had to be designed in such a way that it introduced students to the real world of engineering, to how engineers set about doing their work, and to the way they analyse and solve problems. In addition it was decided to aim for a course: Where the focus was on learning and not on teaching; Where students were active and not passive; Where learning was fun and rewarding; Where creativity and innovation were rewarded; Where rote learning was discouraged; Where students could be confident in their preparedness; Where a culture of life-long learning was engendered; Where there was a high degree of professionalism; Where the ability to communicate effectively was demanded; Where students in a class really got to know each other and learned the benefits of working co-operatively; Where students met and were able to interact with the core staff members of the Department.
It is believed that, to a greater or lesser extent, all these aims are being achieved. The feedback from students in course evaluations has been overwhelmingly positive about the course and what they are achieving from it.

The Course Format

The course requires students to each complete 36 assignments. To ensure that confusion is kept to a minimum, all assignments have been designed to follow the same pattern. They are each run over 3 lecture periods; a single lecture period followed by a double lecture period on the following day. During the single lecture period the assignment is outlined by a lecturer and the necessary background information and theory are presented. Students are then required to do some homework in preparation for the double lecture period during which they are expected to complete the assignment. In short, one lecture period of theory followed by two lecture periods of discovery and practise by the student.

Assessment Criteria

In keeping with Astin's paradigm that "student involvement, high expectations, fair assessment and rapid feedback are the necessary ingredients for fostering true educational effectiveness", a continuous assessment system has been implemented. This too, to avoid confusion, follows a similar pattern. Each assignment has three components that are assessed; a homework task; a short 5 minute test at the start of the double lecture period; and an assessment of the assignment itself. Students do the homework and assignment tasks in groups, while tests are done on an individual basis. Every effort is taken to keep the group size at two.

Assessment of each component is made in one of five categories. 4 marks if the task has been exceptionally well done, 3 marks if well done, 2 marks if just satisfactory, 1 or 0 marks for unsatisfactory work. To ensure that high expectations dictate, marks are not aggregated; the lowest mark of the three is awarded as the overall mark for the assignment. This system minimises one of the biggest problems associated with assessing group work; the possibility that a students will sit back and allow others in the group to do the work and still get a good mark.
The short tests, based on the homework assignments and done on an individual basis, ensure that students are kept honest. The tests are purposefully kept simple and straightforward. The objective is to ensure that each student has done the prescribed preparation for the assignment.

Another concern with continuous assessment that needed to be overcome was the one where students, once they have got 50% of the final mark and they know that they can no longer fail the course, become strategic and re-allocate their time to other pursuits. In calculating the final mark, a factor is built into the calculation that takes into account the number of assignments failed, or not attended, and the previously attained marks are reduced accordingly. This system works very well. Marks for assignments contribute 65% towards the overall final mark.

The most recent student survey asked the question, “Is the continuous assessment mark you achieved to date a fair reflection of your performance?” Figure 1 shows the results obtained. There was a favourable response to this question with 77% of the class rating the course Very Fair or Fair.

![Figure 1, Results on assessment question](image)

Running in parallel with the assignments during the first six weeks is an introductory module. The objective of this module, which is run by a dedicated specialist team organised on a faculty basis, is to address some of the more general problems students have. These involve basic computer skills, academic survival skills, personal development and motivation, career planning, report writing and an introduction to the workings of Departments and the role of the Faculty. To ensure that students attend this module and take it seriously it contributes 10% towards the overall final mark.

Two class tests make up the balance. The first contributes 5% and the second 20% to the final overall mark. To encourage students to start a proper filing system and keep the notes and handouts they are given as easy reference for future years, the tests are
open book. Students are allowed to bring whatever notes they wish with them into the test venue.

**Promoting increased student interaction**

An Internet website, to which each student has access, has been of tremendous benefit in promoting better student interaction. These include:

*Feedback of results*

The website has fulfilled the aim of rapid feedback. When the course was first offered in 1995, a major issue raised by students was the need for an up to date mark sheet. In a paper-based environment, it is not practical to publish a mark sheet of this complexity on a daily basis with only minor updates occurring between postings.

With the website, marks are available as they are captured. A histogram showing how everyone in the class is currently performing is simultaneously updated to allow individuals to compare how they are doing based on the performance of their peers. Inverse peer assessment of this nature is a critical aspect of the student's self-evaluation process.

The reaction of the students to their marks being available to anyone from anywhere that wished to see them was initially a concern that proved unfounded. Individuals are given the option of not having their marks displayed but no one has requested this.

*Frequently Asked Questions (FAQ's)*

Introducing a Frequently Asked Questions (FAQ's) section to the website has all but eliminated unnecessary time being spent answering simple non-content related questions outside of the lecture periods such as, “To whom must I give my doctors note?” or, “What is in the test next week?” This is not an attempt in any way to limit the interaction between the students and the lecturers concerned but has resulted in more content-focussed questions being asked.

As part of this section of the website is an email submission form where a student can (anonymously if desired) send a request to the course co-ordinator for information about some issue they may have. A response to this form of request is seen by the co-ordinator as a priority. A professional approach is demanded from our students and a
rapid response from the co-ordinator ensures that this professional environment is maintained.

If there are similar such issues raised by more than one student then this question and its answer are added to the FAQ.

Comprehensive listing of the Modules
All the assignments to be undertaken by the students during the year are available to both view and print if required. This serves a dual purpose. The first is to give students an easy way of replacing, at their expense, handouts that they invariably loose. The second is to facilitate the desire of a section of the class to read ahead and investigate future modules.

Core Staff presenting the Modules
One of the previously defined objectives was to allow students to meet and get to know core staff members of the Department at as early a stage as possible. There is a link on the website from each staff member that presents a module to his or her own comprehensive information page on the official Mechanical Engineering website. This has created a new dynamic within the Department where senior staff members who normally do not have any interaction with first year students are now actively involved at this level.

Using the Internet to facilitate the distribution of predefined Project Modules
These assignments are designed in the form of standalone modules that can be used by anyone who has a need to introduce one of the topics that are covered in the course. As discussed earlier, these modules are available in full from our website to be used as required. Various institutions have used selections of the modules and feedback on content and design has enabled their continual improvement. The only request in the use of these modules by others is for the co-ordinator to be notified of the fact. This will enable the supply of supporting documentation and copies of tests used to examine the progress of the students.
Introducing the Modules

The 36 modules have been carefully designed to introduce students to a broad spectrum of engineering and to prove to them that they need to have a sound grasp of the fundamentals if they are going to succeed in engineering. They also help to show what an engineering degree entails, and what will be expected of them in the higher years.

Because of constraints on equipment, laboratory space etc. for some of the modules, we have had to divide the class into 6 groups of 16 students. To accommodate the 6 groups at any one time, 6 different assignments are run concurrently. This process is repeated 6 times to allow each of the groups to do the 6 different assignments.

Modules that have been developed range from Systems Thinking; product dissection to highlight design, material and manufacturing aspects; using computers for modelling and systems control; development of electrical and electronic systems; model building and testing; to the Engineer in Society. A comprehensive description of all the available modules is available from the website.

Potential for Institutional Collaboration

These modules have been refined over the past 5 years and are now well focussed and encapsulate what are considered to be the core engineering skills required by Mechanical Engineering students. Other institutions are welcomed and encouraged to use these standalone modules. It is only requested that the co-ordinator be informed as it is by incorporating continued feedback that the modules will continue to be improved to the advantage of the students.

The World Wide Website can be found at http://www.meceng.uct.ac.za/~mec104w.

References.


5. ECSEL, *Redesigning the First Year*. ASSE Prism, May 1993, pp30-33

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