WORKLOAD IN ENGINEERING COURSES AND HOW TO REDUCE IT

Jean Armstrong

School of Electronic Engineering,
Faculty of Science and Technology,
La Trobe University,
Bundoora, Victoria 3083,
Australia.

ABSTRACT: Excessive student workload has been identified as a major problem in engineering courses in Australia. Excessive workload means that students have little time to develop interests outside engineering and causes students to adopt a surface rather than a deep approach to learning. The high workload is the result of a number of factors including the rapid development of technology, courses being structured around historical development, the ready availability of photocopiers and overhead projectors and the culture of engineering. This paper discusses what a reasonable workload is for today's students who come from a wider cross-section of society and have greater and different demands on their time than those of earlier generations. A number of practical methods of reducing workload are suggested including reducing course content and instead developing lifelong learning skills, restructuring courses to take account of new tools like Mathematica and teaching some topics using a 'big picture' rather than an analytical approach.

INTRODUCTION

Course overload in engineering courses in Australia has been identified in a number of important publications as a major issue. For example one of the recommendations of the recently released Exposure Draft Report of the Review of Engineering Education [1] was

> That Deans take steps to reduce overloading of curricula and the formal class contact time required of undergraduate students in favour of alternate modes of learning and expanded opportunities for extra-curricula activity and for engagement with industry.

The results of the Course Experience Questionnaire [2] published by the Graduate Careers Council of Australia indicate that engineering graduates believe their courses were overloaded. The Engineering/Surveying grouping of fields of study had a more negative rating on the Appropriate Workload Scale than any other grouping.

This paper explores

- why engineering courses have such a high workload,
- what is a reasonable workload for engineering students in the context of today's society,
- what measures can be taken to reduce the workload in engineering courses.

REASONS FOR HIGH WORKLOAD

The reasons for the high workload in engineering courses in Australia are due to a complex combination of changes in technology and the culture of engineering faculties.

Rapid Development of Knowledge Base

The first and most obvious reason for course overload is the rapid development of technology. New developments are being made every year and conscientious engineering academics try to incorporate this information in their undergraduate courses. There has also been an increase in the number of management type subjects included in engineering courses. Consider, as an example, some of the subjects included in the Communication Engineering course at La Trobe University. Topics taught in first year now include 'Philosophy and Ethics of Engineering', 'Introduction to Professional Communications', 'Introduction to Engineering Management', 'Introduction to Computers and Structured Programming'. Twenty-five years ago few, if any, of these topics would have been taught in a first year engineering course. Many of the topics taught in the final year course, such as 'ISDN Systems', 'Optical Fibre Systems', and 'Image Processing' have only come to the fore in the last decade or so.

The Problem of What to Leave Out

The problem faced by anyone trying to develop the curriculum for an engineering course is not what to put in, but what to leave out. Often curriculum committees can agree that the content should be reduced but not what should be discarded. Specialists in a particular topic area often view their area of interest as more important than other areas. Academics usually want to do the best for their students and are reluctant to omit anything that could be useful to any graduate.

Courses Structured around Historical Development

There are a number of more subtle reasons for overload. Academics often understand a subject and teach it in the way in which they have learned it, as a result, courses are often structured around the historical development of a subject when there might be other approaches which miss out many of the intermediate steps and which would result in a more direct and efficient learning process for students.

An example of this arose when the author was developing a new course in telecommunications. Discussions with academics and those in industry often followed similar lines - asked how they would structure a new course in telecommunications the response was usually that they would start with basics. Asked what they considered the basics of communications they would typically say 'amplitude modulation and frequency modulation - that sort of stuff'. Yet many modern communication systems such as local area networks and optical fibre systems use baseband transmission in which no modulation is used. Most of those who still considered amplitude and frequency modulation as fundamentals would never, or rarely, use these concepts in their work as communications engineers.

Deep learning and 'soft options'

Excessive workload causes students to adopt a surface rather than a deep approach to learning - they attempt to pass examinations by memorising facts rather than by understanding the material presented. The problem of overload can only be solved by all staff members acting together. If an academic acting alone reduces the content in the subjects which he or she teaches with the intention of allowing the students time to take a deep approach, students tend instead to devote the available time to their other overloaded subjects. There are also cultural pressures on any staff member presenting 'easier' courses - they have to justify presenting a 'soft option'.

The Role of Photocopiers and Overhead Projectors

The ease with which photocopied notes can be produced and the ubiquitous overhead projector have made it easy for academics to overload courses. Twenty-five years ago most lectures were presented by the lecturer writing notes on a blackboard for the students to transcribe. Some, but not all, courses were closely tied to text books. The amount of material which could be covered in a lecture was limited to what the lecturer could write on the board in an hour. Now that many courses use photocopied handouts and the means of presentation is usually the overhead projector much more material can be covered in an hour, but the number of contact hours have not been reduced to take account of this more efficient process.

Engineering Academics - an Ageing Population

Reference has been made a number of times in this paper to what happened twenty-five years ago - why is this important? Because this is when most academics were undergraduates. Statistics on the age distribution of engineering academics in Australia [3] show that in 1994 50% of engineering academics were forty-five or over, 65% were forty or over. Most engineering academics received their undergraduate education in the days when lecturers wrote notes on blackboards and students copied them down. Most were educated before courses became so overloaded and perhaps are therefore unaware of the impact of this on learning.

Collapsing Bridges!

An argument sometimes made is that, if course content is reduced, then graduates will not be technically competent. This is usually stated in terms of 'bridges falling down' - if engineers do not have enough technical knowledge they will design bridges which will fall down. To date most 'engineering' disasters such as Three Mile Island, Challenger and Chernobyl have not been as a result of shortcomings in the engineering design but more often due to failures in communication, lack of ethics, operator error, poor ergonomic design, or decision makers suffering from sleep deprivation.

The Culture of Engineering

The idea that engineering courses are overloaded is not accepted by all. Many engineering academics believe that hard work is a virtue in its own right. This is often explained in terms of 'preparing them for a life of hard work as an engineer'. Many engineering academics express the belief that engineering students should devote many hours to study. In one recent example it was recommended that the official workload should be 48 hours per week (24 contact hours and 24 hours of private study) and that a forty hour week was to be considered a 'minimum effort'. In the past the author has even heard figures like 60 and 70 hours mentioned as what should be expected of students.

It is interesting to speculate whether this belief in the virtue of hard work is related to the fact that almost all engineering academics are male. In an earlier paper [4] the author showed that there was a correlation between the results on the Appropriate Workload Scale of the Course Experience Questionnaire distributed by the Graduate Careers Council of Australia and the proportion of female academics in a field of study.

WHAT IS A REASONABLE WORKLOAD? WHAT IS A POSSIBLE WORKLOAD?

Views on what is a reasonable workload for engineering students are very subjective and depend to a great extent on an individual's value system, for example how much importance is given to breadth of experience in fields other than engineering, how much importance is put on personal and social development. Do we want engineering students who read the newspapers, are aware of current social and political issues, have friends, contribute to the domestic chores of their household, keep fit, or is the only measure of success ability to pass engineering exams?

There is also the question of how workload is measured- if the only measure is contact hours then no allowance is made for subjects which require significant amount of independent study.

What is a possible workload for engineering students may have changed over the last few decades. With the greatly increased enrolments in university courses and other changes in society, many engineering students of today have, compared with those of earlier generations, greater and different demands on their time. Many have to work part-time to support themselves while they study, some have to travel long distances each day to attend university, students may be expected to take a share of household duties.

The author's view is that engineering students should have time to lead a balanced life with time for sleep, friends, exercise and still have time for one significant outside interest. The form this outside interest might take would depend very much on the individual student's circumstances but would include things like a serious involvement in sport or hobby, a part-time job, or significant family responsibilities.

Calculating the time available after the activities above and sleeping, eating, and other essentials reveals that the total time left for contact hours plus private studies is about fifty hours per week. The author believes that this is an absolute maximum and that few people can continue to study efficiently for this number of hours over more than a few weeks. It is often the case that the best, most effective, students are those who work for shorter hours but adopt a deep approach to learning.

HOW TO REDUCE WORKLOAD

There are many ways in which the workload for engineering students can be reduced. Changes which may also result in graduates better suited to the engineering workforce of the twenty first century.

Reduce Course Content - Develop Lifelong Learning Skills

The first change is to accept that engineering courses can not cover every topic that may be of use to every graduate. Even if this were possible, technology changes so rapidly that every graduate would soon be faced with new developments which they would have to learn about. A much better approach must be to try to design courses which develop the lifelong learning skills which graduates will require in a rapidly changing world. To develop lifelong learning skills students must be given suitable tasks or projects which require them to seek out information [5] and to understand technical information, not from lecture notes, but from books, journals, the World Wide Web or from personal contacts.

Teach Topics at Different Levels

A second way to reduce the workload is to consider whether it is appropriate to treat every subject in the same way. Typically engineering courses take a very mathematical, analytical approach, but is this the only useful way to approach every topic? As a practising engineer it is often useful to know in broad terms what the applications and limitations of a device or technique are. If, based on this knowledge, the engineer decides the device or technique is applicable to a particular situation he or she can find out more.

Traditionally, very few engineering topics are taught using this 'big picture' approach. One reason may be that it is more difficult to assess subjects taught in this way. Assessment will more often involve long essay type answers which students dislike writing and which involve some subjective judgements in marking. It is much easier to mark examination questions which have a simple numerical answer. However it can be argued that questions which require students identify and bring together a number of relevant facts and explain their significance in answering a problem are much more closely related to many of the tasks required of a practicing engineer than conventional engineering examinations.

Restructuring Courses and Knowledge

It was noted earlier that often courses and knowledge are structured around historical development and by the lecturer's ways of knowing. Perhaps course content could be reduced by reconsidering what are the essentials of a topic and what are efficient ways of reaching an understanding of these essentials.

Some of the new computer packages may be used to produce more efficient ways of learning. Taking an example from mathematics, the author's understanding of integration and differentiation is based on many hours spent with pencil and paper solving problems, nowadays could students learn the concepts and applications of integration and differentiation more efficiently using one of the many mathematics packages such as Mathematica?

Smith charts are a graphical method of solving transmission line problems, they avoid calculations using complex numbers. Recently while waiting for a printout I watched a Smith chart being printed out on a laser printer. Would Smith have developed Smith charts if he had had access to a Pentium and a laser printer? I think not - yet the understanding of that lecturer of transmission lines was probably based around Smith charts. Smith charts are still frequently used in data sheets so perhaps students still need to know about them - but is it an efficient route to an understanding of transmission lines?

There are many other examples from the field of electronics - Karnaugh maps, phasors, poles and zeros where perhaps a different approach might be taken if we rethought the subject. No doubt there are many similar examples from other branches of engineering .

CONCLUSIONS

Excessive student workload is a major problem in engineering education in Australia. It prevents students adopting deep learning approaches and developing wider skills and interests which are also important for life as an engineer in the society of today and the future. This paper has identified some of the reasons for excessive workload and shown a number of ways in which student workload can be reduced and at the same time improve learning outcomes without increasing staff workload.

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