

## Computer aided teaching of Mathematics

### Background

The massive decrease in mathematical knowledge of students entering the higher education system has alarmed those teaching Mathematics, and generally the decision makers in higher education. This phenomena has been signalled for engineering education for the first time, but it *does not characterise the Engineering education only. The results of students entering some of the Natural Science faculties of universities were even lower in the past few years.*

### The Decline of Mathematical Knowledge and Skill of Engineering Students

There is a growing concern in the engineering communities of many technologically advanced countries, including Australia, Sweden and the United Kingdom, that too many graduate engineers are deficient in their mathematical knowledge base and mathematical skills. The UK Institute of Mathematics and its Applications issued a report in 1995 expressing this concern. The engineers were perceived to lack the necessary understanding of important mathematical concepts and ideas, the ability to manipulate mathematics efficiently, and thus the facility for applying their mathematics in the engineering context.

R. Sutherland, and S. Pozzi reporting for the Engineering Council, in 1995 stated [1]: „There is unprecedented concern amongst mathematicians, scientists and engineers in higher education about the mathematical preparedness of new undergraduates.” This concern is almost universal around the world. They reported that the majority of engineering lecturers surveyed said that the mathematical knowledge of first year undergraduate engineers is weaker and more variable nowadays than it was 10 years ago. The situation has not changed since, but the decrease of mathematical knowledge continued even further.

They identified two main reasons for these changes:

- the broadening of university entrance requirements to enable students to enter through vocational or other non traditional routes; and
- curriculum changes in the students pre-university education.

Our colleagues teaching in technical universities reported similar experience in meetings held at Miskolc (2000), Göteborg (2002), Wien (2004), and Kongsberg (2006) at the SEFI MWG European Seminars on Mathematics in Engineering, many of these concluded in the so called SEFI-MWG Core Curriculum.

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### The aims of teaching mathematics

It seems that the above indicated problem, the dramatic decline of mathematical knowledge and skill of students entering the universities is leading to the increasing responsibility of those teaching mathematics. This responsibility has got at least two faces.

First the need to address the recruitment problem and selecting the students entering the university with abilities to finish their studies.

Second - and this is nonetheless important - to offer the necessary mathematical knowledge, based on minimal background preparedness.

The section is an overview of some of the actual problems in the teaching of Mathematics in European universities, taking into account the experience of national and international conferences in the subject and the SEFI Mathematics Working Group activities.

### **Measures undertaken by universities**

European universities have not been unaware of these problems and a range of measure have been taken to address them. These measures include:

1. reducing syllabus content, replacing some of the harder material with more revision of lower level work;
2. developing additional units of study;
3. establishing mathematics support centres;

Each of these measures has its own disadvantages.

Reducing syllabus content may help the weaker students to pass; however, removing more advanced material disadvantages the more able students who become less well-prepared for the more advanced and more analytical parts of their engineering study.

The use of additional units of study to cover basic material means that there is no need to remove some more advanced material from the curriculum. However, this approach has a number of practical difficulties. Ideally the basic material should be covered before the "standard" mathematics course is started, but there is no time for this.

Mathematics support centres are outside the formal taught course structure. They provide students experiencing difficulties with supplementary resources and additional tuition. However, those working in such centres know that this approach does not reach the root of the problem. The less well-prepared students need a systematic programme of study in order to give them a coherent body of mathematical knowledge rather than one riddled with gaps.

### **The root of the problem, and possible solutions**

We may start accepting that the classical way of teaching is not enough to face the present situation, and they must be supported by new, different teaching methods facing the changes and expectations. The following may remedy the present deficiencies:

- Analysis and renewal of syllabus content
- Extending the use of computer based methods for teaching
- Introducing collaborative learning forms to increase the students' participation in the teaching process.

### **Renewal of the content of Mathematical teaching**

This measure has constantly been on the agenda of universities as every faculty tries to keep pace with the changing demand. This is why a final version can hardly be found. Also the renewed syllabi are usually the product of several people or a team of experts. In consequence to

the Bologna Declaration universities will necessarily introduce drastic changes in their present day educational profile. This will also mean significant changes in the content of the courses. In the renewal of subjects within mathematics one of the most important step is the proper formulation of basic concepts of mathematics. Regarding the concept of function to be the most important in engineering training many papers discuss the role of function in mathematics for engineering and some of its seemingly unusual usage, e.g. the definition of sequences, vectors, matrices and graphs. The technical examples will enable the students to familiarise themselves both with the mathematical concepts, theorems and their practical application.

The concept centred renewal must concentrate on the training of logical thinking and appropriate deduction, we will argue for inductive- intuitive teaching in this respect. A significant issue in engineering education is articulated in the quote from Walek: „One never knows when some abstract theorem of arithmetic will be introduced in technical application. This is why students must get familiar with some special chapters of mathematics.” Consequently we suggest the teaching of some of the abstract chapters of mathematics, such as the concept of inverse semigroups, Hamilton quaternions, or Eulerian paths for graphs as chapters that can be introduced in engineering education.

### **Computer aided teaching**

Authors like Burton et al, 1992 [2], and Mason, 1994 [3] conclude that employers of all graduates, but in particular employers of engineering graduates, are emphasising the need for employees who have learnt how to learn, are flexible, have good problem solving and analytical skills, and have the ability to work as team members. New technologies are having a significant impact but their introduction both at the workplace and in the classroom or lecture theatre can lead to the uncritical use of tools without accompanying changes in understanding about learning and, consequently, teaching and assessing needs. **It is important for the students to have a thorough mathematical knowledge which enables them to become conscious users of softwares and to properly understand and check the results. To require the students to learn how to use mathematical software to carry out tasks which are plainly most efficiently done by computer (such as solving large systems of simultaneous equations).**

**It is important that students do not just learn the relevant commands in the software package available to them. They must learn to use this packages discerningly, from a base of mathematical knowledge that will inform them, when the computer solution may be unreliable.**

Recent years have seen an increased interest in the research of computer aided teaching. and it have been accumulated various experiences presented in several papers. The author has come to the conclusion, based primarily on his own experience, that the majority of teaching methods aided by computer can be most effective in tutorial groups of relatively few participants, and especially when these are conjoined with active methods.

The author's opinion - the product of the number of participants and the efficiency coefficient is constant - has been proven by conclusions like:

- computer based learning and distance learning, according to experts in the subject, is most effective when 10-15 students and their teacher are sitting in front of the computer at the same time though fare away from each other, thus learning together.

- the research in computer software applications has proved that it is most efficient in the teaching of mathematics in case of smaller groups.

**The rapid changes in computer and information technology, the increase of computer power available and the complexity of mathematical software (Maple, Mathematica, MatLab, MuPad and Derive) now accessible to the students cannot be ignored;** at the very least it demands a radical re-think on the way in which topics in the curriculum could be presented and does have an impact on the teaching of Mathematics in most of European universities. There are two connected but distinct issues related to this expansion in the availability of computer and software, which are of considerable importance to the mathematics curriculum. The first is that **new approaches to teaching and learning are made possible**. The second is that **enormously sophisticated mathematical software is now commonly available which allows the tackling of problems of such size and complexity that only a few years ago have been parts of research activities**.

### **Active participation of students - collaborative learning methods**

The opinion of students who graduated some years ago reveal that in their professional work they only make use of a part of their knowledge of mathematics gained during their university education. However they make excellent use of their logical thinking acquired by learning mathematics.

It is important for the students to be able to formulate their own working method. For this they must be provided help. Students must learn how to study. The application of the present Leonardo project method can be very important in their university studies together with its secondary effect. The structure of the teaching process is very important as well as a thorough knowledge of questions based on each other. Concepts must be defined clearly as well as the clear and brief definition of theorems is important. In order to handle the time available for teaching and for efficiency we all try to demonstrate theorems and explain their applicability instead of their proof. This is what is made easier by emphasising the aspects of the theory of Mathematics, the computerised demonstrations, the models and the counter-examples.

It is important to find the description and discussion of technological applications in the teaching of mathematics. It is important as well to interpret the theoretical part and the results of the calculations. The unity of teaching-learning, however includes the proper evaluation of the results in addition to the practice of the calculation technique.

Nowadays the speed of the methods have become as important as propriety. Teaching the students how to work independently would need such software and hardware background and adequate guidance.

The contents of our actual Leonardo project, European Virtual Laboratory of Mathematics is meant to enhance the teaching and learning Mathematics, and if the experience of collaborative learning and the consultations made available in the Mathematics learning centres designed by the project partnership, we will, probably, contribute to the main goals of the project.

Despite the falling level of secondary teaching more and more educational forms appear in which mathematics is given a more dominant character. The motivation of students to study is reducing which can be handled only by introducing newer methods. A process of standardisation has started all over the world and in Europe, which can be seen in the CORE CURRICULUM elaborated by SEFI-MWG [4]. New trades and specialisations are disappearing, while others

seem to grow out from nowhere. The systems of conditions seem to be rather hectic. Often they get changed and modified after the phase of introduction. Market orientation makes education vulnerable. The major objectives of teaching of mathematics for engineering students can be seen in the demands of the lecturers in engineering subjects, the post-university applications and the consumers demands. It is important to select a coherent part of mathematical knowledge, which can be well taught. It is similarly important to know a wide range of methods of teaching and learning and to get acquainted with students. abilities, the testing of their prior knowledge.

#### References

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4. SEFI-MWG CORE CURRICULUM [<https://learn.lboro.ac.uk/mwg/core.html>]