The 11th SEFI-MWG European Seminar on Mathematics in Engineering Education

- some impressions, Dr. Mike Barry, University of Bristol, England.

The 2002 seminar of the SEFI Mathematics Working Group, with a central thread of the Development of Teaching of Mathematics was held at Chalmers University in Gothenburg, Sweden on 9-12 June. The main themes were:

- Distance Education
- Lifelong Learning of Mathematics
- Evaluation of Computer Aided Learning of Mathematics
- Computer Aided Assessment

with emphasis on curriculum development and in particular the SEFI-MWG Core Curriculum.

Curriculum and Introduction

The SEFI-MWG is no stranger to Chalmers University having held its 4th European Seminar there in 1987. That event, hosted by the late Prof Lennart Råde, marked the first attendance at such a seminar of delegates from Eastern Europe and included such themes as the importance of computers in engineering education. In the early 1990s, under Råde's leadership the Group was able to expand its activities across the whole of Europe and has become much respected across the world for its advice and direction in engineering mathematics education. In shaping the Core Curriculum in 1992, the Group advised upon a collective syllabus in engineering mathematics that devoted about one half of the time to analysis and calculus, and about one sixth each to linear algebra, probability and statistics, and discrete mathematics. Numerical methods were to be infused throughout, the increasing and ever-changing role of the computer was emphasised and the curriculum itself was hierarchically subdivided into Core Zero (pre-university), the common core itself, and higher elective course elements. Prof Stan Ackermans, then SEFI president wrote the preface to the Curriculum in which he claimed that technology must be understood to be mathematically based and not just engineering based.
Ten years on, the SEFI-MWG, building upon its experiences of the intervening seminars, has re-edited the core Curriculum. Geometry is of key importance to engineering and is now a major item. The hierarchical levels have been rationalised into Core Zero and the Core plus electives into three tiers. The various syllabus topics and subtopics have been defined in much greater detail with a special new emphasis placed upon learning outcomes. The new curriculum also catalogues the decline in core mathematical knowledge of university freshmen students, an effect that was once most noticeable in the United Kingdom, but which is now being felt across the whole of Europe. The Group Chairman, Dr. Leslie Mustoe, opened the 11th European Seminar on this theme, giving an informative account of the progressive reduction in school-level mathematics in the UK since the 1960s. Forty years ago UK students were mathematically well prepared by international comparison, although employers and others complained, even then, as to the lack of modelling skills. Nowadays, not only is knowledge reduced but combined with the lack of student drill and practice, examiners have been driven into writing a detailed 'training

style' of questions via prompt and feedback, rather than the shorter and more vague 'educational style' of question in which the onus is on the student to recall and assemble the necessary steps in a mathematical argument. Other delegates too, at various times in the seminar, echoed this change in examination style and there seemed to be agreement that the pressure to produce good marks from school students, rather than the generation of understanding, was the driving factor.

Discussion of the Themes

The Seminar consisted of both plenary sessions, which I will return to later, and shorter talks and general discussions. As always at such a gathering, the unrehearsed questions and comments that come from the floor very often have as much value as the talks themselves. The detail and content of the Curriculum has rarely been discussed at Seminars of the Working Group, mainly because an executive task group has dealt with this, but there has always been interest as to how the curricular model might be followed elsewhere. Marie Demlova and Jiri Grigor, CVUT Prague, chaired a discussion on the possible extension or enlargement of the Curriculum to postgraduate level. It might be necessary to separate out pure and applied mathematics particularly when considering links with engineering. Also, there should be a clear distinction between the largely undergraduate level mathematics needed for the continuing professional development of the engineer as opposed to the new mathematics at postgraduate level needed in emerging specialisms.

The Internet did not exist when the Curriculum first appeared but it has revolutionised distance education. Tatania Govalcova and Martin Gavalec have recently moved to the new Czech University at Hradec Kralove. This institution has a special role in serving unemployed and mature people and is putting together e/courses. Many other delegates too are investigating the use of WEB and e/courses for distance learners but there is concern that the WEB is 'chaotically organised', or more to the point, how would an e/teacher know that an e/student might be a young Gauss who had summed 100 natural numbers in a totally original way. Distance education, the lifelong learning of mathematics, and teaching and learning for understanding are subjects that have been much in focus in the more recent MWG Seminars. This is not surprising as they are closely linked to the transitive drill and practice of Core Zero that young engineers need. Quite a few speakers addressed these issues. Peter Kortesi of the University of Miskolc spoke about the use of case-study type projects based upon Polya's 'How to Solve it' and the work of the CEEPUS Network H-127 of international student exchange in Central and SE Europe. This is supported by computer based teaching materials and links with the MacTutor Apple-Mac System at St Andrews University.

A special discussion on Internet e/Math course was chaired by Daniela Velichova of the Slovak Technical University in Bratislava in the final afternoon session of the seminar. By this time many of the delegates had shared thoughts about this new form of computer-aided education and many agreed that it was still finding its way. This was evidenced by the number of questions put to the group discussion rather than actual answers given. HTML is not properly mathematically compatible so maybe a breakthrough will not come until some of the interface problems are overcome. Other talks addressed this too. Petr Habala, CVUT Prague, listed some of the advantages and disadvantages, e.g. applet capabilities in interactive graphing and cumbersome handling. Odd Bringlid, told the Seminar that The Xmath project, funded by the Minerva scheme, is aiming to bring about a prototype mathematics course on the Web, hopefully involving the brand new technology behind WebMathematica and MathML. Angela Schwenk, TFH Berlin, has been using computer aided education packages to assist with the marked decline in mathematical preparedness

of new students in the 1995-2000 period but has found that great selection and care is needed; she commented that care and realism need to be applied to any form of computer use in the teaching process and that many mistakes in curriculum development had been made by the excessive fascination that teachers have for computers. It will be interesting to see where e/Math is by the next Seminar.

Assessment is an issue of increasing importance. Following the Chairman's opening remarks many delegates were concerned that examinations and other written assessments in both schools and universities are becoming increasingly aimed at optimising the return in marks obtained rather than student understanding. Ulrica Dahlberg, a PhD student at Chalmers University, has been studying 45 courses given in linear algebra. All of these have a written examination, 10 have coursework and only 3 an oral examination. No claim is made as to what assessment method, if any, is most effective in measuring true understanding, but it may be true that assessment patterns elsewhere in undergraduate mathematics follow such like ratios; and, as has been explained, written examinations results can be wildly at variance with the real understanding of students. Mike Barry and Jon Sims Williams of the University of Bristol wish to share assessment material with members of the SEFI-MWG and others across the international community. The Test and Learn or TAL system of multiple-choice questions (MCQs) is aimed at the repeated reinforcement of key knowledge and skill. They would agree with the views voiced by other delegates that MCQ testing can only be part of a wider assessment strategy but such testing is accepted by students at Bristol as a real motivator, a powerful revision aid, and something well worth development within the Group.

The Plenary Sessions

The three plenary sessions held at the start of each of the three days closely captured the general flavour of what was discussed at other times within the main themes. They raised other issues too, some in contrast, but all relevant to the themes and the achievements of the SEFI-MWG. Prof Leone Burton of Kings College London, following the Chairman on Monday, claimed that the unnecessary separation in the thinking of tutors between the teaching and learning of formalist mathematics, and their own processes of researching, obscures the relationship between those processes, at every level. In an international survey of 70 mathematicians Leone discovered that they might think in a style that could be visual, analytic, or conceptual, but vary rarely in all three styles. The survey indicates that the public view of the 'loner-geek' academic archetype mathematician is quite false and most are in fact team workers. The aim in teaching engineering mathematics might therefore be to emulate the manner and form of the non-classroom research environment into student learning strategy. Some very useful ideas as to how to achieve this were put forward. For example, students are expected to be managers of their own learning but can be quite uninvolved in the learning process if they merely receive lectures or maybe answer a set question. If however they are made to 'ask a question', they become the agent of learning, they find their own voice, and they are forced to reflect upon their own understanding up to that point. Commenting upon a serious issue often raised at the Seminar, namely the removal of engineering mathematics teaching from mathematics departments to engineering departments, Leone suggested that improperly prepared engineering students would have learning difficulties no matter who taught them, and that the adoption some of her ideas might help to overcome some of these, but the questions of 'team-working', not to mention the acquisition of modelling skills, remain difficult issues.

The other plenary speakers over the three days were Mårten Levenstam of Volvo Cars in Gothenburg, Tuesday, and Sue Pulko of Hull University, Wednesday. A motorcar is well

recognised to be a compact but hugely intricate unit involving considerable complexity in engineering design. Not only that, its safety commands a high price in terms of both cost and human emotion. Volvo has throughout its history been a key player in car safety research and to this day holds the most extensive database of traffic accidents in the world. Mårten listed a few of the key issues involved in a frontal crash, from the length of the car to role of the airbag and then discussed some of the mathematical skills related to crash analysis. These include a basic background of what might be called first year engineering mathematics, plus a related numerical and programming background. How often has this been heard from industrialists speaking at other conferences on the mathematical education of engineers! At a higher level, in dealing with motor car design generally, engineers obviously need to know about such things as how to solve partial differential equations using software packages based upon finite element methods, and once again there is a need for skills in problem solving. Mårten likened this skill need to some of the training given to PhD students ranging from searching literature in a library to preparing oneself to be questioned. Comments from the floor indicated that some institutions were building in such skill acquisition into undergraduate programmes and that there was a role for a catalogue of real problems with 'mistakes' and 'where things go wrong'.

Sue Pulko, speaking on behalf of the 'Progress' project at Hull University, said the project was set up to investigate the causes of the high attrition rate of undergraduate engineering students in UK universities. The UK sadly still leads the way in the inadequate mathematical knowledge of students on arrival, and the project so far has identified this as a main cause of students abandoning their courses. All too often, UK universities have been trying to make this good by providing additional supporting mathematics in the first year of study, but this imposes extra burdens on those students already disadvantaged. 'Progress' has conducted a weighted needs analysis across 51 categories of mathematics provision in the first year. This measures out the amount of mathematics to be studied by those students, giving only the minimal essentials when necessary, though there would need to be catching up later. Such measures may be interim and the UK engineering institutions will need to be satisfied that sufficient mathematics is being covered, but Hull University is having success with the scheme, possibly reinforced by teaching methods which limit each hour of programmed time to a 20 minute lecture followed by small-group examples classes.

Conclusion

When the SEFI Mathematics Working group was formed in 1982 working with computers was well established for programming and the related use of software packages. The processing power offered tempted many teachers towards the huge potential advantages of computer aided learning. Few recognised that educational and learning technology needed to expand in proportion and many mistakes were made. Delegates at the 2002 Seminar have computers in their working rooms and at home and have a much more proportionate view of computers in education. This is just as well because the home computer offers a quantum new opportunity in Web-served and e/learning. As yet much material is still confused and unfocused so the new challenge to teachers is to enable the student to elicit the signal from the chatter and noise. Developments such as the Xmath project should be looked out for, but the Holy Grail is a workable and friendly Web style mathematical language of communication.

The decline in mathematical knowledge, especially at the school-university interface has worsened considerably since the Group was formed. The reasons behind this are complex, but pressure on the curriculum, and a wide variety of social and cultural changes, now

being felt internationally, are believed to play their part. The role of the Group is to advise upon how to cope with this within the engineering curriculum. It will be interesting to see whether initiatives such as the Progress project and its weighted needs analysis will be adopted elsewhere.

Real understanding underpins lifelong learning. Some school and university curricula now concentrate on a core of mathematical knowledge but there is major doubt as to whether traditional written assessments actually measure true understanding. 'Just-in-time' teaching is but a knee-jerk reaction, which at best delivers surface learning. However carefully designed 'callisthenic-type' assessments which students can repeatedly access by computer or elsewhere, will give a transitive and reflexive dimension to that learning, thereby deepening it. In a metaphor, 'get to know an island country by firstly driving a car along the main highway that crosses it coast to coast, then do the same journey on foot following a different route, repeating such a journey till you have set eyes on every hill and valley; do this often enough and you will be able find your way about from every aspect and corner'.

Metaphors apart, the mathematical skills a young engineer needs for modelling equate to complete fluency, confidence and practice in the basics of the language. Not surprisingly these are hard to achieve, and have been the object of repeated discussion at conferences over the years. Overcoming them is difficult, but if a student is attracted to learn by an automated medium which reinforces his understanding in a useful, unstressed, and even entertaining way, then stamina will improve and the joy of achievement be felt.

The challenges to those who wish to develop the curriculum in the 21st century lie in taking forward the learning technology to match the enormous power of the computing technology. For example, in developing assessment databases, the entire Curriculum needs to be classified and subdivided into a hierarchy of topics, subtopics, subsuming priority and so on. The SEFI Mathematics Working Group has made a marked contribution to this already in specifying a Core Curriculum inclusive of learning outcomes.

Thanks go to Dr. Carl-Henrik Fant for organising the 11th European Seminar so effectively and enjoyably in Gothenburg. Dr. Leslie Mustoe, Chairman for the past six years has very ably steered the Working Group through a time a change and challenge. He will step down at the end on 2002 to let the present Vice-Chair, Prof Marie Demlova take over. The 12th European Seminar is planned to take place in Vienna in mid-2004.