Mini-symposium on ‘Mathematics Education’ held at the British Applied Mathematics Colloquium (BAMC)
University of Nottingham, 7 – 9 April 2009.

The British Applied Mathematics Colloquium (BAMC) is the largest annual meeting of applied mathematics researchers in the UK, attracting around 300 academic staff, postdoctoral researchers and a strong attendance by postgraduate students. The meeting lasts over 3-4 days held around the university Easter vacation period and rotates between UK mathematics schools/departments. The meeting topics span all areas of applied mathematics and many of current university applied mathematics lecturers started their career from participating in the BAMC. The meeting is a mixture of invited plenary lectures from world-leading experts, themed mini-symposia and parallel contributed talks from participants. In recent years BAMC has also hosted a mini-symposium within the broad area of mathematical education with support from the Maths, Stats & OR Network (MSOR Network).

During the Easter 2009 period, the BAMC was hosted at the University of Nottingham and a mini-symposium organised for a session focussed to a general BAMC audience. It is pleasing to report a good level of attendance and balance of participants. Brief abstracts are given below identifying topics for each of the four invited presentations to give an overview. Extended articles for three topics are also collated to provide more extensive outcomes from the mini-symposium; the fourth has already appeared in the MSOR Connections article: Newton’s Mechanics: Who Needs It? Mike Savage, Charlie Stripp and Janice Gardner, MSOR Connections Feb 2009, Vol. 9 (No. 1): 4-6.

The MAGIC experience from a lecturer’s perspective

The MAGIC group runs a wide range of postgraduate-level lecture courses in mathematics, using Access Grid videoconferencing technology. By the time the BAMC takes place the MAGIC consortium will have delivered graduate lectures for two years. The presentation is primarily targeted at supervisors and their students and aims to discuss issues centred around the curriculum, technology and learning and teaching.

Study skills in a mathematics degree

Whilst we would all agree “creating autonomous learners” is a hugely important aspiration doing something about it is much more difficult. The diversity of prior student attainment in mathematical and language skills bases of our cohorts often means students may need to make up missing ground independently or risk failure. An increasing realisation is that students do not have initially the required skills and we are largely wasting their time spoon-feeding yet more maths into them if, ultimately, they cannot stand on their own feet. They may graduate yet still be unemployable
So just what is conceptual understanding of mathematics?

There is substantial anecdotal evidence to suggest that students entering many mathematical sciences courses in HE are less well prepared than previously. However, since 1992 the number of students who have obtained a good “A” level grade has increased from 35% to over 65%. A random inspection of a selection of “A” level papers shows that much of the content has remained comparable though the approach may be more methodologically based. In a small pilot study we set out to compare student’s mechanical skills with their conceptual understanding in order to investigate this apparent dichotomy.

Newton’s Mechanics: Who Needs It?

This question challenged delegates at a symposium, held at the Møller Centre, Cambridge, in July 2008. Outcomes are available in a formal report but can be summed up:

• UK engineering, science and industry prize highly the skills of mathematical modelling and problem-solving grounded in Newton’s mechanics; and,
• There has been a significant decline in the take-up of mechanics at 16-19 following curriculum changes in 2004. Students in 30-40% of schools and colleges now have minimal access to mechanics modules (at most one).

Further details are given in the article mentioned above.

The MAGIC experience from a lecturer’s perspective

James Blowey, Durham University

Introduction

The giving and receiving of a video-conferenced lecture is a completely different experience to that of a standard chalk and talk or even an electronic talk where the speaker and audience are physically present in the same room. A successful ordinary lecture will not necessarily translate into a successful video-conferenced lecture.

This article is an overview of existing video-conferencing efforts and a personal review of the Mathematics Access Grid: Instruction and Collaboration (MAGIC) experience. The MAGIC group provides a wide range of postgraduate-level lecture courses in mathematics; for further details see: http://maths.dept.shef.ac.uk/magic/. Approximately 450 hours of postgraduate mathematics lectures are delivered each year and MAGIC is one of six EPSRC funded training centres designed to deliver inter-institutional courses.

The article by Penny Davies [1] gives an excellent reflection and overview of the first year of the Scottish Mathematical Sciences Training Centre. In Australia the ICE-EM (http://www.amsi.org.au/index.php/ice-em/access-grid) was established to strengthen education in mathematics and its contemporary applications through improved mathematics education in schools, undergraduate studies and research training. The major difference between MAGIC and the ICE-EM is that MAGIC is focussed on the delivery of postgraduate lectures.

Background

I was unable to find much educational literature discussion of video-conferenced lectures for mathematics or other technical disciplines at a University level, see [2] for an example of a multi-disciplinary large scale schools project in Australia. Experience of web-based teaching of mathematics in the UK are:

1. The Open University and Further Mathematics Network use Elluminate to supplement distance learners support via online tutorials.
2. A case study on Mathwise [3] concluded that:
   • timing of collaborative sessions is a fundamental issue; and,
   • far more preparation is needed for a successful video conference lecture.
3. In a study [4] on “Motivate” authors give consideration on how the use of a new technology changes the basic pedagogy; video-conferencing is seen to enhance the quality of the learning experience, and to provide something not achievable in conventional teaching.

I believe that many of these lessons were understood and resolved when MAGIC began in 2007/8.

Structure and delivery

All of the original twelve institutions (now eighteen) which were part of the original MAGIC bid have delivered at least one lecture course. One of their tasks is which to determine the courses for each year. At the end of the first year 170 hours of courses were dropped and replaced by 180 new hours in 2008/9. In 2009/10 nodes were offering 260 hours of new courses on top of existing courses which I believe to be a good sign of the success of MAGIC. Moreover, some repositories are adding MAGIC as open source material for the academic community, such as Intute which is a free online service provides a database of hand selected web resources for education and research.

The Access Grid software used allows the lecturer to export four desktops of the PC and three cameras. Most sites have a Mimio board which allows the lecturer to write on an ordinary whiteboard, with up to 8 different coloured ordinary pens, which gets converted in real time into an electronic image which in turn can be broadcast on one of the PCs desktops. Most of the lecturers produce pdf
Local experiences

With the visible equipment the main issues tend to be with the batteries housed in the wireless devices and the Mimio board pens – one quickly becomes an expert in the symptoms and their resolution as the pain is unforgettable. Externally, other sites microphones can cause interference but these can be switched off. Thankfully JANET has been robust, as has been the Access software. The equipment is expensive and that should the PC go wrong it might take some time for our node to become operational; as insurance we purchased a separate software license so that we could give/receive lectures with two desktops should the worst happen. At Durham students are given a 20 minute training session on how to use the equipment and access to MAGIC pages covering: What is MAGIC? Access to the on-line MAGIC resources; Receiving a MAGIC lecture; Giving a MAGIC lecture; Reported problems with MAGIC and solutions.

There is no summative assessment and although I have set some formative assessments (with access to limited solutions for self-assessment). Final student assessment of the course is administered, by individual universities but may be via an optional exam provided by the lecturer on request, or in some instances by a student portfolio.

Benefits for students and staff

Students have benefited as I believe MAGIC eases their transition from undergraduate degrees into Ph.D.'s and also to gain background. Postgraduate conferences have been held, not MAGICally, which bring together students with a common experience who would otherwise not meet and makes our students feel part of a larger community. The Access Grid system has brought several additional benefits for staff including: MSOR arranged seminars, participating in remote meetings and recording video-clips for use elsewhere. I believe the challenge is to build on the success of the Access Grid to use utilize the equipment for the benefit of the mathematical community.

References


Study skills in a maths degree

Martin Greenhow, Brunel University

When I was asked to give this talk, I wondered how I was going to stop it turning into a ‘let’s moan about students’ session. From the reactions during my talk and afterwards it was clear that I wasn’t the only one who is frustrated by the perception that many students’ attitudes to study will hinder the academic development of perhaps as many as 50% of students. Regardless of where their fixation with marks, rather than with understanding, stems from, we have accepted students in good faith and it is incumbent on staff and students to alter their rather entrenched and short-termist attitudes. This must start with study skills, especially good time management, without which little progress can be made. After all, even the most brilliant lecturer cannot teach them anything if they are not there! Many students merely sample a lecture course, attending lectures sporadically and tutorials rarely, until just before exams when panic sets in. Some attend only if there’s ‘something in it for them’, as captured in the following email:

“You never told us that it would be the last opportunity to get feedback for marks, that is abit out of order dont you think, especially as if you have told us prior to this more people would have turned up.”
No wonder 'maths is boring' if all they learn is a set of recipes rather than a coherent body of knowledge firmly grounded in underlying concepts and definitions. No wonder also that some staff feel compelled to set very formulaic and closely similar exams to avoid high failure rates. But isn't this the tail wagging the dog? We must certainly help students to achieve but we must also be prepared to fail those who do not! Many second year students would benefit from 'repeating' their first year i.e. doing it properly for the first time.

So the fault lies with the students, and yes, I am moaning! Full-time students need to make study their number one priority (and not fit study round part-time employment which often exceeds 15 hours per week); if not, they may scrape a degree, but be unemployable, lacking most of the transferable skills picked up by serious students during the courses (time management, note taking, the ability to write good English and a capacity for sheer hard work). The pertinent question for staff is how do we help them? Is this even our job and do we have the skills to do so anyway?

For STEM subjects in HE, the necessary study skills are somewhat different to those for text-based and school-delivered courses. Hence many of the books/resources available do not seem to hit the mark for our purposes. A Google search on study skills shows the top 10 comprise study skills sites aimed at the latter, whilst only my Study Skills Online (http://people.brunel.ac.uk/~mastmmg/ssguide/sshome.htm) addresses the former. This site has proved hugely popular with recent hits from over 100 countries. So this site might provide a basis for your provision for all your students – indeed the good ones will probably learn the most (as usual).

Of course, merely pointing students at the above site is no more likely to be effective than pointing students at the library and saying “Go and learn calculus”. One needs to embed meaningful and prolonged provision for the development of study skills throughout the first year (at least). This raises three questions:

1. Who should provide the teaching?
2. How should the provision be embedded in the curriculum?
3. What mathematics should be left out to make room for this?

Whilst the gold-standard provision might be thought of as everyone doing their bit in the context of their modules, thereby requiring minimal curriculum change, this is problematic in two ways: staff may simply not have the skills to deliver it (and even resent having to do so), and students may ignore it and still pass each module. The other extreme of enlisting specialist support staff is also problematic. A middle way seems feasible, namely running a study skills module, lead by a maths academic but with input from support staff such as librarians, learning support tutors and computer staff. Such an arrangement is well-known in other disciplines (biosciences, computer science etc where such core skills modules also cover numeracy and basic algebra) and is relatively straightforward to assess. The downside is that there is perhaps one less module of 'proper' maths with consequent curriculum changes. However, I suggest that this requires only a repackaging of module content, rather than omission of topics. With the correct study attitudes and skills, students can be expected to achieve more and, to put it bluntly, work harder. Success might be measured not just in marks, enhanced final year projects and employability, but in their perceptions of their degrees, as in the NSS survey.

The final part of my talk explores what can be done using computer-aided assessment to assist students with writing mathematically, English grammar and referencing. Admittedly, only the basics can be tested by a machine, although with good question design, one can exploit random parameters to generate many realisations, as for straight mathematical questions, e.g. see [1]. Although development is at an early stage, the need is clear from the following (fairly typical) email:

> “hello greenhow, i'm sorry to disturb u, u know i asked u for da finance CAA test. u told me that i got 50% so did u updated da grade yet. coz ma result was C without including da finance grade. i just wana make sure it dat i got same grade eventhough includin da finance grade. thanks”

Even allowing for the informal nature of email and its intended humor (I hope!), it is clear that this student does not (cannot?) write grammatically and hence may be unemployable in any graduate job. Having corrected several earlier emails, my reply to this one was: you is gettin da grade B now ... respect! It should have been U is getting ... of course, which goes to show that writing correctly requires sustained practice. A study skills module would be a good place to do this, placing communication skills centrally within a mathematics degree.

**References**

So just what is conceptual understanding in mathematics?

Douglas Quinney, Keele University

A recent pilot study at Keele University, [1], investigated the difference between procedural knowledge and conceptual understanding in students beginning their studies towards a mathematics degree in September 2008. This study has now been extended to over 500 students who started their studies in September 2009 and presented is a preliminary report.

**Student survey**

The MSOR project asked students to undertake a short test consisting of 5 questions and then complete a questionnaire on their general attitudes and thoughts on the test. The test questions were:

1. Tabulate the function \( y(x)=\frac{10}{x}+40x+5 \), \( 0<x<6 \) and use the result to plot this function. Find the slope of the curve at \( x=0.5 \) and comment on the result.
2. Classify all the turning points of the function \( s(t)=At^{-1}+Bt+C \), where \( A \), \( B \) and \( C \) are all positive.
3. Two positive numbers, \( x \) and \( y \), have product 100. Express the sum of these numbers in terms of \( x \) and use the calculus to minimize this quantity.
4. A cylindrical can has radius \( r \) and height \( h \). If the can holds 250 cubic units and has minimum surface area, show the height is twice the radius.
5. The cost of keeping a car is the sum of insurance and running costs. Daily insurance cost is inversely proportional to the age of the car. The daily running costs is the sum of a fixed cost, including tax, and a maintenance cost that is proportional to the age of the car. For what age is the total daily running cost smallest?

These questions all use the same mathematical procedures but the conceptual understanding required to do so increases with succeeding questions. The mathematics required is covered in all C1 modules specifications at A-level and as such it might be expected to be completely internalized by all the students in the study. Each question was marked for method, the ability to carry out the necessary computation/method, and conceptual understanding. The questions were moderated by a group of academics that teach first year mathematics courses. The marking scheme was validated by the same group.

**Results**

The test and survey were carried out at seven universities in the UK and the results are given in Table 1. In addition survey results are shown from a number of universities in the US, Turkey and Australia and broadly similar results were obtained.

Whilst the test was carried out individually at most universities, two departments requested for the test to be administered as a group activity because collaborative working was an inherent part of their course. High scores for these two universities are obvious in Table 1, though it is not clear whether their results are due to the collaboration that took place or merely a pooling of group knowledge. To validate the test, students were also asked to give their A-level mathematics grade; the comparison between the test results and A-level is given in Table 2. In addition, students were invited to specify the exam board responsible for their A-Level examination and so it was possible to compare the performance of the students in the survey by exam board. Just under 50% declared their exam board but the numbers of students who did reply were significant enough to conclude that the test scores were the same for all exam boards on a like for like basis.

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Table 1 – Results of survey by university
Table 2 – Results by A-level grade

Finally, the staff at the universities in the survey was asked to predict an average score from experience of their students; and similarly those attending the mini-symposium. Results are given in Table 3 and show a wide, though remarkable uniform, discrepancy.

Table 3 – Comparison of student results with staff predicted results

Student questionnaire

The students taking the test were also invited to complete a short questionnaire looking at their attitudes towards mathematics, how they studied mathematics prior to tertiary education and how appropriate they felt they were prepared for the test. Approximately 430 students responded; less than 30% had been encouraged to work in groups at school and almost 70% thought there had been insufficient time to discuss mathematical ideas either inside the classroom or elsewhere at school. It might be noted that the two departments that had asked that the students take the test as a group activity scored the highest marks. Surprisingly, about 15% thought the questions easy but nearly 90% thought they were appropriate for students starting a mathematics degree.

Preliminary comments and conclusions

Only a limited number of students were able to complete all five questions; all but one of these simply repeated the same mathematical argument for each question, only one student actually linked the questions and referred back to previous problems and thus made the conceptual link we might hope for. When asked at the end of the test whether they had noticed anything about the questions, only two students remarked that the mathematical content of the questions was the same; both these students had studied the IB rather than A level. A detailed analysis of student responses will be provided in a separate report. However, at this point in the project there are a number of questions requiring detailed investigation. Firstly, bearing in mind the homogeneity of the results obtained so far, should we even expect the majority of current students to have progressed to a deeper level of conceptual understanding, or simply expect them to be at a level where their understanding is driven by assessment to the extent it remains superficial? A subsidiary question is whether we really understand the background knowledge and mathematical sophistication of students arriving to study mathematics at college level. Secondly, the next stage of this project was to repeat the test with students beginning of the 2009 academic year, but bearing in mind the uniformity of the results perhaps it should also be given to final year students to compare their mathematical progress. This has already begun at Keele, and I'm looking for other institutions who would be willing to participate.

References