MSOR connections

The newsletter of the Maths, Stats & OR Network
Volume 11 No. 3 Autumn Term 2011

Mathematical Sciences HE Curriculum Innovation Project

Guest edited by Peter Rowlett

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Maths, Stats & OR Network
National HE STEM Programme

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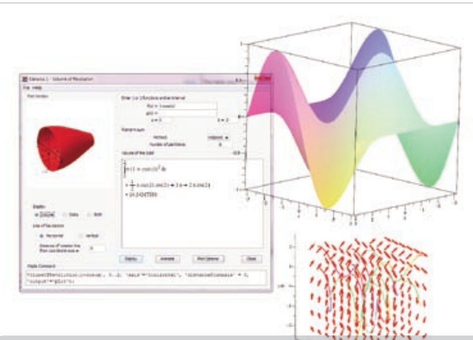

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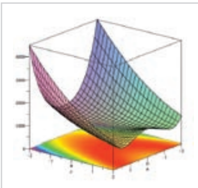

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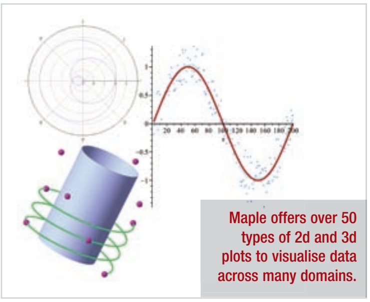

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MapleT.A.™ 7

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Much of the work reported in this special issue of MSOR Connections is supported by the National HE STEM Programme, which is funded by the Higher Education Funding Councils for England and Wales.

Contributions are invited – please contact the editors.

The articles and reviews from this newsletter will shortly be published and available for download from the Network's website at **www.mathstore.ac.uk/newsletter**. The site also gives access to many other useful resources and information regarding Network events.

If you would like to subscribe to receive regular paper copies or unsubscribe to the newsletter, please email **info@mathstore.ac.uk**.

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the Maths, Stats & OR Network

Welcome to this special issue of MSOR Connections, themed around work undertaken as part of the National HE STEM Programme. This includes work organised by the Network under the Mathematical Sciences HE Curriculum Innovation Project and work organised by other HE STEM partners.

In a break with tradition for Connections, work is reported in sections. The first contains an account of our HE Mathematics Curriculum Summit and work which addresses the recommendations for curriculum development made by that Summit. The remainder of the articles are arranged according to several areas of activity: graduate skills; employer engagement; mathematical thinking; technology; inclusive curricula; engineering maths; outreach and widening participation through schools and colleges.

As well as full articles and short reports, throughout this issue 'Projects in brief' give a hint of the wide range of work in mathematics supported by the National HE STEM Programme. For a full list of supported activity in mathematics and the rest of STEM see **www.hestem.ac.uk**.

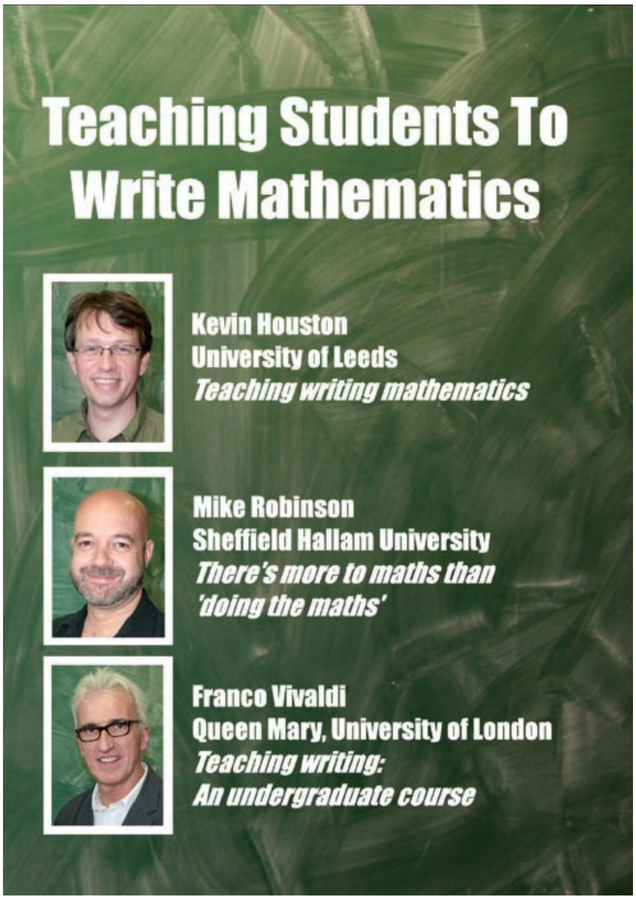
I hope that you will find the articles informative and thought provoking. Two key aims of the National HE STEM Programme are long term, sustainable change and community-building. With these in mind, I encourage you to consider adopting the ideas reported in these articles and to contact me or the authors if you would like to discuss or ask for further information on anything you read.

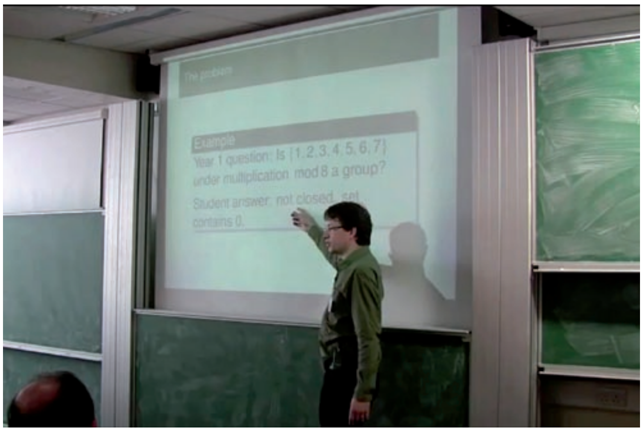
Peter Rowlett
HE Curriculum Innovation Officer

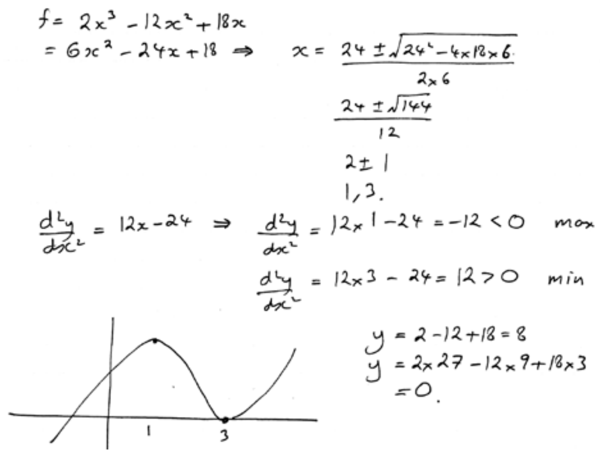
Contents

Teaching Students To Write Mathematics.

A DVD produced and edited by Kevin Houston.







Students don't write mathematics correctly. They throw down a mess of symbols with the answer underlined at the bottom and rely on the examiner's intelligence to get the marks. Teaching them to write in a more orderly and logical way has numerous advantages: it makes marking easier; allows students to demonstrate understanding (or not); and forces an improvement in their thinking skills. Expressing their ideas clearly and correctly is a valuable skill for graduates in further study, employment and life in general.

The three talks on the DVD describe this important and current topic. Featuring a mix of practical advice and stimulating theory this DVD will be of interest to anyone teaching mathematics.

The DVD-ROM content contains the presentation slides, further reading and sample teaching resources.

You can watch the videos and download the extra content, or download a copy of the DVD you can burn to disc yourself, from

www.kevinhouston.net/dvds/writing-math.html

Summit recommendation:

Development of maths-focused resources equivalent to already published generic resources on improving students' communication skills (see page 4).

Alex Fenlon

The National HE STEM Programme

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The National HE STEM Programme supports Higher Education Institutions in the exploration of new approaches to recruiting students and delivering programmes of study within the Science, Technology, Engineering and Mathematics (STEM) disciplines. It is supported through a three-year grant from the Higher Education Funding Councils for England and Wales (HEFCE & HEFCW).

The Programme's aim is to influence long-term university practices at an individual, departmental and faculty level by engaging staff directly in the development and delivery of activities. Through collaboration and shared working it seeks to embed sustainable approaches that will be a core part of Higher Education STEM sector practice for years to come.

Programme activities are focused upon the disciplines of Chemistry, Engineering, Mathematics and Physics which were deemed strategically important and vulnerable by the Higher Education Funding Council for England (HEFCE) in 2004.

Since its inception in 2009 the Programme has initiated a wide range of activities across England and Wales of varying scales related to its three areas of activity:

A. Widening participation within the STEM disciplines at university level, by supporting HEIs to work with those currently within the school and FE sectors;

B. Higher education curriculum developments focusing upon course delivery and design and student support to enhance student knowledge, progression and skills;

C. Encouraging those currently within the workforce and society to engage with further study to develop enhanced knowledge and skills.

The Programme has been working with a range of partners to encourage and support projects to investigate the three themes above across the four disciplines, including work in mathematics with the Institute of Mathematics and its Applications, the MSOR Network and **sigma**.

Over 350 projects have been initiated under the Programme, with those covering mathematics activities including a group exploring the transition to university mathematics led by Garrod Musto in Bath, a major national collaboration on e-assessment in maths and stats led by Bill Foster at Newcastle and a project making explicit links between the HE maths curriculum and applications in science, technology, business and industry led by Vivien Easson at Queen Mary, to name just three!

This special edition of Connections presents some of the work supported by the National HE STEM Programme. Find out more about work undertaken by the Programme from **www.hestem.ac.uk**.

Summit Outcomes

Peter Rowlett

Acting on recommendations from the HE Mathematics Curriculum Summit

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Work completed as part of the HE Curriculum Innovation project, part of the Mathematical Sciences Strand of the National HE STEM Programme.

The Mathematics HE Summit took place at the University of Birmingham on 12 January 2011, organised by the Maths, Stats and OR (MSOR) Network as part of the Mathematical Sciences HE Curriculum Innovation Project within the National HE STEM Programme. This brought together: Heads of Mathematics or their representatives from 26 universities offering mathematics degrees (about half of those in England and Wales); Education representatives from the Institute of Mathematics and its Applications, the Royal Statistical Society, the Operational Research Society and the Council for the Mathematical Sciences; members of the National HE STEM Programme, **sigma** and the MSOR Network; and several individuals.

The day was chaired by Prof. Duncan Lawson and opened with a debate, in which Prof. Alexandre Borovik of University of Manchester proposed and Jon McLoone of Wolfram Research opposed the motion: 'We believe that memory, subject knowledge and technical fluency remain vital for undergraduate mathematicians in the digital age'. Following this, breakout groups discussed the topics: 'We can't let them graduate unless...'; 'If maths students can't communicate in writing or speak in public – is that my problem?'; and 'If most maths graduates "aren't confident" in handling unfamiliar problems – should we care?' After lunch the Summit received feedback from the morning discussions and an update on employer engagement activity from the Mathematical Sciences Strand by David Youdan. The Summit heard and discussed presentations from Prof. Jeremy Levesley on 'Taking control of the assessment agenda' and Dr. Neil Challis on 'What do the students think about their Maths degrees?' A final set of breakout sessions considered the topic: 'Imagine there is £100k-£150k in total available to support curriculum development across the sector, how best should this be targeted and what are the priority areas?' These final discussion groups produced a list of recommendations for prioritising curriculum development.

Reports of the debate and discussion sessions as well as reports by Levesley and Challis on their presentations are available in a report via the MSOR website [1]. The recommendations from the Summit were taken into project briefs in our third call for funding from the Mathematical Sciences HE Curriculum Innovation Fund. The focus of this section of Connections is on the recommendations made in the final discussion sessions and the work taking place this academic year, supported by the HE Curriculum Innovation Fund as part of the National HE STEM Programme Mathematical Sciences Strand, to address these priorities.

References

1. ROWLETT, P. (ed.), 2011. *HE Mathematics Curriculum Summit*. Birmingham: MSOR Network. Available via: http://mathstore.ac.uk/?q=node/1730

Mathematical Sciences HE Curriculum Innovation Project

Project in brief: Problem Solving

Summit recommendations:

Collect case studies for how to embed problem solving into curricula. Develop a good practice guide for problem solving and assessment of problem solving. Develop a bank of problems with solutions and extensions.

Project 1: Problem Solving

Project partners: Trevor Hawkes, Coventry University and Chris Sangwin, University of Birmingham
(£36k)

The project's aims are to:

1. champion the value that problem-solving contributes to students' development as mathematicians, to their enjoyment of mathematics, and to success in their courses.

2. make it easier for lecturers to incorporate problem-solving meaningfully in their teaching and assessment.

3. find out what other HE mathematicians are doing successfully in this area, to build on their experience, and to disseminate examples of good practice.

We will: consult widely in HE; carry out case studies; write a good practice guide; create problem banks with solutions and examine the role of mathematical software in problem-solving.

Project 2: Problem Solving

Project partners: Sue Pope, Liverpool Hope University and Lynne McClure, NRICH, University of Cambridge
(£20k)

LHU and NRICH will work together to design and develop a cohesive problem solving package which supports HE colleagues in embedding problem solving into their courses, through:

a) a guide to the various pedagogies of problem solving and its assessment, in collaboration with the other Problem Solving project;

b) a virtual problem solving environment which hosts problems suitable for a range of undergraduate mathematics courses, ideally hosted by NRICH;

c) case studies generated through the development and trialling process, in collaboration with the other Problem Solving project.

Mathematical Sciences HE Curriculum Innovation Project

Project in brief: Industrial Problems for the HE Curriculum

Summit recommendation:

Development of a bank of industry-based problems, suitable for undergraduate students, developed in consultation with industry partners and vetted.

Project 1: Industrial Problems for the HE Curriculum (maths)

Project leader: Martin Homer, University of Bristol
(£29k)

This project aims to create a diverse online repository of industrial case study problems, suitable for use throughout mathematics undergraduate programmes. It will build on the unique and proven track record of the Department of Engineering Mathematics at the University of Bristol for collaborative research between mathematicians, engineers and applied scientists. This will be an evolving resource: as well as problems, relevant data, and suggested solution techniques, there will be an online discussion area, to encourage collaborative input and feedback from users. Existing problems can be adapted in light of experience from across the community, and new problems continually added.

Project 2: Industrial Problems for the HE Curriculum (stats)

Project partners: Neville Davies, RSS Centre for Statistical Education, University of Plymouth and Shirley Coleman, Industrial Statistics Research Unit, Newcastle University
(£10.5k)

The project will engage with an industrial/business partner to identify real problems solvable using data interrogation, graphical and statistical modelling methods. With advice from university colleagues, these will be synthesised into formats for teaching at three levels. At level one the problems will be posed so that solutions can be obtained by using individualised samples. At level two students may need to do research and collect secondary data that will help them solve the problems. At level three students will collect primary data, possibly interacting with the organisation that provided the problem. In their solutions students will provide written discussions/reports.

Mathematical Sciences HE Curriculum Innovation Project

Project in brief: Developing Graduate Skills uptake projects

Summit recommendations:

Building on the case studies collected by the mini-project 'Developing Graduate Skills in HE Mathematics Programmes' (reported on pages 16-19).

Three mini-projects are being supported to spread good practice identified in that collection of case studies.

Project 1: Maths Careers: Greenwich graduates where are they now?

Project leader: Noel-Ann Bradshaw, University of Greenwich (£1k)

Inspired primarily by Case Study 1, the University of Greenwich's Maths Careers afternoon will enable current maths students to hear first-hand from recent graduates how and when to apply for jobs and what different careers entail. Representatives from several industries including banking, insurance, teaching, transport, analytics and mathematical modelling will be invited to give presentations and answer questions on their careers. Most presenters will be early career mathematicians who will be able to understand the needs of our students. An Employability Skills Guide will be prepared showing students how to develop their skills and explaining the link between final year options and career choices.

Project 2: Progress Files – Greenwich Implementation

Project leader: Tony Mann, University of Greenwich (£1k)

Progress files were used in Case Study 7 by SHU to enhance employability by promoting self-reflection. The results of the case study are encouraging and suggest a better way of achieving the reflective activities which have been introduced, with partial success for final year students, at Greenwich. The project will implement the SHU system at Greenwich to enhance our existing procedures. If the pilot is successful it is envisaged that the system will be extended and more fully integrated with the Greenwich Virtual Learning Environment (VLE).

Project 3: Mathematical Presentation and Communication Skills within the Core Curriculum

Project leader: Andrew Neate, Swansea University (£1k)

Mathematics students are expected to absorb how to present mathematics in a precise and succinct manner from the books they read and by observing their lecturers. However, students often do not see this as important and often fail to engage in developing such transferable skills. The importance of focusing on these study skills was highlighted in Case Studies 12 and 14. We hope to raise the importance that students place on these aspects of their education from the very beginning of their time at university. This will be done through a short series of workshops covering transferable skills as part of their normal lecture programme and reinforced through feedback on assignments and general tutorial support.

Mathematical Sciences HE Curriculum Innovation Project

Project in brief: Assessment

Summit recommendation:

Research project to provide a review of existing theory of assessment schemes for mathematics and collect examples of good practice on use of different assessment methods for mathematics. Explore exemplars of innovative approaches to assessment. Develop a repository of assessment teaching resources. Develop a package of question design support for new lecturers.

Project: MU-MAP – Mapping University Mathematics Assessment Practices

Project partners: Paola Iannone, University of East Anglia and Adrian Simpson, Durham University (£50k)

This project will survey assessment practices across university mathematics and develop resources to share good practice. It will also focus on the costs and effects of the change required to implement good practice in new contexts so that lecturers can both see what others are doing and understand the practical issues involved if they wish to adapt those methods to their own practice. Outputs will consist of the MU-MAP website (including databases of literature and electronic versions of all outputs), the MU-MAP Good Practice Book with sections covering different forms of assessment practice, dissemination workshops and professional and research articles.

Track the progress of all these projects through the Mathematical Sciences HE Curriculum Innovation Project website: **www.mathstore.ac.uk/hestem**

Mathematical Sciences HE Curriculum Innovation Project

Project in brief: Being a professional mathematician

Summit recommendation:

Develop a collection of teaching resources on the development of mathematics - stories from history and more recent development of the discipline. These should aim to counter a view of mathematics as a static, completed body of knowledge and instead encourage awareness of the process of doing mathematics. They should develop students' awareness of the culture of mathematics.

Project partners: Tony Mann, University of Greenwich and Chris Good, University of Birmingham
(£10k)

This project will produce a set of case studies on "being a mathematician". Some will be historical, some based on interviews with present-day mathematicians, statisticians and OR practitioners in academia and industry. Teaching materials will include documents of these case studies (on paper or in MP3 format), worksheets and possible seminar questions looking at topics including employment opportunities, mathematics research and its impact, gender and race issues, the role of professional bodies, and how these different mathematical practitioners see themselves as mathematicians. A workshop will discuss how this body of material might fit into the undergraduate curriculum.

Mathematical Sciences HE Curriculum Innovation Project

Project in brief: Models of industrial placements

Summit recommendation:

Pilot of undergraduate students gaining experience of working in industry through short term placements (e.g. 2 hours per week).

Project leader: Tony Mann, University of Greenwich
(£2k)

As well as a traditional year-long sandwich placement, the University of Greenwich has a new 'Mathematics Industry Placement' 30-credit module taken during the final year. This involves short-term placements of the kind recommended by the Summit so, rather than initiating a new pilot scheme, a mini-project exploring the Greenwich pilot has been commissioned.

This project will contribute a report on the experience of running this scheme in order to capture information that could help other departments considering such schemes. This project will also run a workshop at Greenwich to allow discussion of placements for mathematics students and sharing of experience from elsewhere.

Mathematical Sciences HE Curriculum Innovation Project

Project in brief: Views of graduates on the HE curriculum

Summit recommendation:

Research to collect the feedback of graduates in employment on the mathematics HE curriculum.

Project leaders: Matthew Inglis and Tony Croft, Loughborough University
(£5k)

This project seeks to understand graduates' perspectives on the undergraduate mathematics curriculum. Specific foci will be on understanding:

i. the mathematics that graduates use in their day-to-day work;

ii. graduates' perceptions of generic skills developed by studying undergraduate mathematics;

iii. specific components of the undergraduate mathematics curriculum which graduates believed helped develop these skills;

iv. specific skills which were not developed during degree courses which participants believe could and should be;

v. how, and how well, graduates believe their curriculum was delivered and whether with hindsight different delivery mechanisms may have left them better prepared for the workplace.

Stephen O'Brien, Joanna Mason, Jean Charpin and Martina O'Sullivan

Student mathematical modelling workshops as preparation for study groups with industry

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The Mathematics Applications Consortium for Science and Industry (www.macsi.ul.ie) is funded by the Science Foundation Ireland Mathematics Initiative grant 06/MI/005.

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Summit recommendation:

Pilot extending the model of the 'study groups with industry' to undergraduate project work.

Editor's note:

Although we haven't taken this Summit idea forward in a project, this report and the student essay that follows were invited to give an explanation of the 'study groups with industry' concept, staff and student perspectives on involving students in such activities and advice on making the format work for students. They are presented in the hope that they might inspire the reader to consider taking inspiration from this format to design an undergraduate group project task or modelling week.

Study groups with industry

Study groups with industry are organised on a regular basis on all continents. In the European context, study groups with industry (as initiated in Oxford University in the 1960s and continued under the umbrella of the European Consortium for Mathematics in Industry (ECMI)) are week long meetings where groups of industrialists, mathematicians and other scientists work intensively on problems proposed by the industrialists. The Mathematics Application Consortium for Science and Industry (MACSI) in the University of Limerick (UL) has been organising a study group every year since 2008. The study group format is standard. Mathematicians and other scientists gather for approximately a week with industrial collaborators to find solutions to a set of problems proposed by the industrialists.

- The first morning, industry representatives present the problems. One must appreciate that the problems presented are usually not mathematical problems to begin with. Typically they are descriptions of a complicated industrial process which is not well understood from a scientific point of view. Usually, there is a specific question of the type 'How might we prevent this happening?' Sometimes, the request is more vague to the effect that if we can help to model the situation, something useful may come from the mathematical solutions. When all problems have been presented, the academic/scientific participants select the problem(s) they would like to work on.
- The first afternoon, subgroups of the scientific participants meet with each industry representative and ask far more detailed questions. Ideally, at the end of the day, the team should have defined in broad terms the approximate goals for the week. It is important to realise that in some cases, a successful outcome at the end of the week may be a properly formulated mathematical problem (i.e., the correct mathematical question).

- During the rest of the week, the group works on the problems and progresses towards a solution. Participants may choose two strategies. Either they focus on a single problem all week or they may decide to hover between different problems. It is really a matter of taste. Some people like to work intensively on one problem: others prefer to make smaller contributions to a number of problems. The industrial partner may or may not attend all sessions. (S)he should ideally be easy to reach if more information is required.
- On the last day, all groups present their results to the industry representatives and the other academics.
- A report describing the work of the group is written in the weeks following the study group and given to the industrial partner.

In a study group one is confronted with real applications of mathematics and must focus on getting significant results quickly. However the first study group one attends can be an overwhelming experience, particularly for students. Apart from the obvious mathematical modelling skills, genuine applied mathematics requires a broad scientific background and the ability to assimilate information in the area of the industrial/scientific application (e.g. finance, physics, chemistry, biology). For this reason, specially designed student sessions are often organised. The goal is to familiarise students with the concept of a study group and with some of the standard techniques and ideas which commonly occur. To achieve this, before the study group, an experienced mathematician runs a session where (s)he uses one or several past (and generally simplified) study group problems with the students. (S)he plays the part of the industrial representative and presents the problem to the students. Using the solution previously obtained, (s)he can guide the students and help them rediscover the results. Working in groups, the students all contribute to the final result and this constitutes an excellent first contact with industrial problems.

Student mathematical modelling workshop

Inspired by the ECMI modelling weeks, MACSI hosted its first student mathematical modelling workshop at the University of Limerick on the 23rd and 24th June 2011, the week before the 82nd study group with industry. The workshop was open to final-year undergraduates, Masters' students and early-stage PhD researchers in mathematics, science and engineering. Students were also strongly encouraged to register for the study group the following week. There was no registration fee, and MACSI, through funding from Science Foundation Ireland, was able to offer free accommodation and meals for all participants. Although a similar workshop could easily be run as part of a graduate course for local students at a much lower cost, we thought students would benefit from working with peers from different backgrounds.

We advertised the workshop through mathematics email distribution lists, and leaflets were sent to all higher-level mathematics departments in Ireland. We were delighted that 38 students participated in the workshop. 15 of these were local students, 15 from other universities in Ireland, and 8 from other universities in Europe. MACSI asked UL mathematicians to lead the problems at the workshop. Two departmental lecturers, two MACSI senior research fellows assisted by a senior postgraduate student supervised four problems which are listed below.

Optimal omelette cooking.
To optimise omelette preparation "Offaly Omelettes" requested guidance on the ideal power of the hot plate used to heat the omelette; the perfect cooking time, before and after flipping; and minimum possible spatula size.

The cooling of concrete slabs using water pipe networks.
Piped water networks are used to remove hydration heat from concrete dams during construction. The aim of the workshop was to provide a measure for the efficiency of practical water network designs, and to estimate the optimal spacing of pipes and pipe length.

Equity option & credit default swap (CDS) Risk Management
Students were asked to find a method for hedging intra-day CDS price movements to increase trade and revenue without resorting to offsetting contracts. Access to the trading floor at the University of Limerick was provided.

Energy efficiency in wastewater aerobic bio-treatment.
Students were asked to optimise plant design and operating conditions to reduce the energy consumed per mass of treated sludge whilst satisfying minimum standards.

Registered students were emailed problem descriptions in advance of the workshop, and on the first morning, as in a study group, each project leader gave a brief presentation about their problem. Following the presentations students were asked to rank their choice of problems 1-4. In the coffee break organising committee members assigned students to either their first or second choice problem, and ensured group sizes were approximately equal (8-9 students).

Each problem was assigned a classroom, with either a white or blackboard, and computers with Matlab and Maple were made available. Over the next day and a half students worked intensively on their chosen problem under the guidance of the project leader. At the end of the second day each group was asked to give a short presentation summarising their work.

The value of these type of workshops was clearly highlighted in the feedback forms. Students enjoyed applying mathematics to tackle real world problems, and working together in a small team, something which is quite unusual during a mathematics degree. Out of the 26 students who completed the feedback forms, 22 felt more prepared to attend a study group, and 25 would choose to participate in a similar event in future. We learnt a lot from running this workshop, and we plan to run a similar event before next year's study group. In response to participants' feedback we hope to lengthen the workshop to 3-4 days, and reduce the group size by increasing the number of problems.

MSOR connections
Student Insert

Ben Nuttall

Mathematical modelling study group

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During the final year of my combined honours degree in Mathematics and Computing at Manchester Metropolitan University (MMU) I received an invitation to a two-day Student Mathematical Modelling Workshop at the University of Limerick in the Republic of Ireland, hosted by the Mathematics Application Consortium for Science and Industry (MACSI). The workshop was followed by the 82nd European Study Group with Industry. The maths course at MMU is highly oriented around real world problem solving involving mathematical modelling, dynamical systems, numerical methods, ODEs & PDEs and contains a strong programming element, so this was something I thought would be good to attend.

My friend Chris and I applied for our places on the workshop and booked our flights. What better way to unwind after completing a maths degree than being put to the test! Not really knowing how useful we'd be in helping solve problems, nor which type of problems we would like to tackle, we began by sizing up the problems set online. I chose a problem on Equity Options & CDS Risk Management because it seemed an interesting situation to work with. The group consisted of both those who had studied financial mathematics and those who hadn't, so there was a mix of abilities and understanding. The finance people got on with what they have done with similar problems, explaining themselves along the way, and others found useful things to bring to the group. I personally looked at the data we had been given, analysed the trends in the evolution of option prices over time and ran a Monte Carlo simulation in MATLAB to demonstrate the effectiveness of the strategy.

The second week was the study group so the lecture theatre was filled out with academics as well as the students who had stayed on. I chose to work on a problem in Electricity Prices and Demand Side Management, looking at estimating usage for a company called Crystal Energy in Ireland who offer electricity to companies at variable tariffs based on consumption. I worked with other members of my group on analysing the company's data in MATLAB and Mathematica. We were able to produce useful information for the group, including isolating volatile periods in the day (e.g. between 12-2am) and in the year (e.g. mid-late December) by looking at the absolute difference (error) between corresponding timeslots and plotting contour maps. A report explaining our findings has been submitted for publication.

As the study group fell after our final exams, it gave us a great insight in to the usefulness of what we had learned at university, indicated gaps in our knowledge and inspired us to attempt to solve problems that arise, small and simple or bigger and more complex problems alike. It gave us both the courage to realise that this is something we could do with our lives, applying our skills in such a real and meaningful way which could lead to significant results in personal, small or large scale industry problems.

James Groves

Enhancing the communication and speaking skills of mathematics undergraduates

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Work supported by the HE Curriculum Innovation Fund, part of the National HE STEM Programme Mathematical Sciences Strand.

Summit recommendation:

Development of maths-focused resources equivalent to already published generic resources on improving students' communication skills.

Project interim report

In June 2011, Lancaster University delivered a substantially enhanced course in Communication and Presentation Skills to 108 second-year undergraduate mathematicians. The course was delivered jointly by staff in the Department of Mathematics and Statistics and CETAD, the Centre for Training and Development. Funding for the course and its increased staffing requirement came from our HE Curriculum Innovation Fund grant of £5,000. The course formed part of Lancaster's credit-bearing MATH390 Project Skills module.

Students were divided into four classes, with roughly 27 in each class – within each class, students formed themselves into six groups. Each class was taught by two tutors – one from the Department of Mathematics and Statistics and one from CETAD. Each student participated in five learning sessions, taking place over three successive Fridays, covering:

- What makes a good communicator?
- Formative assessment: given a previously-unseen article from a magazine, your group has two and a half hours to prepare and deliver a 5-minute presentation on the article. You may not use visual aids.
- What makes a good oral presentation?
- Summative assessment: your group has one week to prepare and deliver a 10-minute presentation on a mathematical result of your choice. You may use visual aids.
- What is teamwork?
- The learning cycle.
- Team exercise: coding and codebreaking.

Students had nine hours' contact time with tutors over the duration of the course.

Feedback on both the formative and summative assessments was given by a group of their peers (immediately following the presentations) and by their tutors (within a week of their presentations). Participants were encouraged to reflect on their performances and their feedback, identifying development points for them to work on.

Participants were able to use their recently-acquired skills in mathematical typesetting using LaTeX, which they had been learning that month as another component of the MATH390 module, to produce high quality slides for their summative presentations.

CETAD devised a detailed marking grid to assess both the formative and summative presentations. The summative presentation marks contribute 10% of the students' overall marks for the MATH390 module.

Between June and November 2011, students will be working on Group Projects. They will be expected to make 15-minute presentations on their projects in November, making use of the skills they have developed in the Communication and Presentation Skills course. CETAD has devised the marking grid to assess the group presentations.

Feedback from the participants was very encouraging. Of the 59 who completed a feedback form: 58 (98%) felt their presentation skills had improved; 43 (73%) rated the quality of the teaching "excellent", with a further 13 (22%) rating it "good"; and 34 (58%) rated the course overall as "excellent", with a further 21 (36%) rating it "good".

CETAD and the Department of Mathematics and Statistics are now working on a project report, which will include materials for dissemination amongst the academic community.

Throughout the development of this project, emphasis has been placed on:

- The incremental development of communication skills;
- The importance of direct personal experience;
- Regular peer and tutor feedback; and
- Opportunities for reflection as a basis for learning.

HE STEM

Project in brief:

Developing a Student-led Employability Audit Toolkit for the HE STEM Curricula

The openly available employability audit toolkit will allows HEIs to benchmark their programmes. Project leader: Barrie Cooper, Exeter. Supported by the South West Spoke.

HE STEM

Project in brief:

2020 Vision: A curriculum for Mathematics graduates for the next decade

Project reviewing the undergraduate mathematics curriculum at the University of Birmingham. Project leader: Chris Good. Supported by the Midlands and East Anglia Spoke.

HE STEM

Project in brief:

Identifying skill gaps of employers and mathematics undergraduates

Project aiming to improve employer liaison at the University of Leicester to increase student awareness of how their skills apply to a commerical environment and enhance their articulation of those skills. Project leader: Jeremy Levesley. Supported by the Midlands and East Anglia Spoke.

Barrie Cooper, Jonathan Gillard, Dave Graham, Jane White and Rob Wilson

Summer internships in sigma-sw

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This work was completed by **sigma**-sw, the South-West and South Wales regional hub of the **sigma** network, part of the National HE STEM Programme Mathematical Sciences Strand, with contributions from individual institutions (Plymouth & Bath).

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Summit recommendation:

Fund undergraduate students to undertake focused summer intern projects within universities.

Editor's note:

*When this idea arose at the Summit, **sigma**-sw[1] already had plans to pilot such a scheme. This article gives a brief summary of the **sigma**-sw summer intern projects within universities during summer 2011. A fuller account, including student and staff reflections, is in preparation.*

With evidence of the potential for undergraduate students to work as research assistants in mathematics and statistics support centres and with a keen desire to develop explicit collaborations between member institutions within the hub, **sigma**-sw piloted a summer intern programme for students across the region which aimed:

1. To provide undergraduates with an opportunity to engage in research activity linked to principles of mathematics and statistics support in HE;
2. To develop effective, working collaborations between colleagues in **sigma**-sw initiated by the work carried out by students during the summer internship and leading to a research portfolio within **sigma**-sw.

Each institution took charge of its own project design and student recruitment during Spring 2011 resulting in the following 4 projects.

Measuring the effectiveness of mathematics support services; Matthew Taylor, Cardiff University with supervisors Jonathan Gillard & Rob Wilson

Providing concrete evidence of the effectiveness of mathematics support continues to be very difficult. We used the internship programme to offer the student a research project which would allow them to develop their statistical skills whilst carrying out exploratory analyses on our support usage data. What emerged from the project was a simulation model, parameterised using data predominantly from Cardiff, that we hope to develop into a functional and informative tool for evaluating the effectiveness of mathematics support services.

Creating a community of practice for maths and stats support staff and an online resource for students; Oliver Bond , University of Exeter with supervisor Barrie Cooper

This project built an online resource for students, not to replicate existing online resources for maths and stats, but to validate them through student review and build

[1]*More information on **sigma**-sw is available from http://www.bath.ac.uk/study/sigma-sw*

a framework for a sustainable student support community. The new site (http://labspace.open.ac.uk/course/view.php?id=7405) will become the online hub for maths and stats support at Exeter and through regular student and staff use, should evolve into a valuable and effective site that is freely accessible to all. Regular contact and feedback with interns from other HEIs has ensured the value of the final output to the wider student community.

What do drop-in usage statistics tell us?; Callum Anderson, Plymouth University with supervisor Dave Graham

An analysis of usage statistics and feedback, including identification of the main areas of demand and patterns of behaviour in students, has been immensely valuable for the SUM:UP (Support for Undergraduate Mathematics at the University of Plymouth) service. This project also compared such statistics for different institutions to identify common or distinctive features, which highlighted several issues in performing such comparisons across different models of provision and using varied means of recording participation.

Helping students learn how to learn mathematics at university; Andrew Kennedy, University of Bath with supervisors Jane White & Emma Cliffe

It is fairly uncommon for students entering a mathematics degree programme to consider, in any great depth, how they learn effectively. By contrast, experience suggests that developing a range of approaches to tackle unfamiliar problems can help students maintain interest and enthusiasm for mathematics at a higher level. We are increasingly keen to get students thinking about their learning, to find ways for them to develop independent study skills which are effective in the long-term, not just at examination time. The online resource developed during the internship will form one component of study skills sessions that will be offered in the mathematics support centre in Bath in 2011/12.

For the project as a whole Aim 1 was achieved to a good degree. Each student spent time researching the background to, and contextualising, their project. Projects were based in, and relevant to, each HEI but students were expected to liaise with students in the other HEIs to test materials, provide data etc. The hub structure enhanced this process by allowing students to receive and respond to constructive criticism from academics and the intern peers. We arranged an initial meeting at Bath and following this the students communicated using a Facebook group and arranged two further meetings, one at Exeter and one at Plymouth. A plenary lecture, planned at these meetings, was delivered by the students at the CETL-MSOR Conference 2011.

The long term Aim 2 has certainly been facilitated by the summer intern programme. Each project involved the development of a resource and/or analysis of mathematics support data. It is now our responsibility to move forward first by trialling materials developed by the interns across the region; then by using this as a platform to create further collaborative research projects.

Selected reflective comments from the student interns are presented below:

Matthew Taylor, Cardiff University: "I thoroughly enjoyed my work on the project, as it allowed me to experience mathematical research, explore a practical application of my mathematical knowledge and network with other students across the United Kingdom. I feel my confidence in my ability to work independently and trust my own instincts and judgements has also benefited greatly. As an added bonus, I found the CETL-MSOR conference a great insight into how the teaching of Mathematics at undergraduate level can move forward."

Ollie Bond, University of Exeter: "I benefited a lot from this project and I'm very glad I participated. I gained some more ideas about what working from home involves and academic research, whilst my teamwork and organisational skills were enhanced. As a group we were able to set up meetings to collaboratively get work done, and we actively shared a lot of ideas."

Callum Anderson, Plymouth University: "This project has been an introduction into academic research and into working within a network of institutes. It has also increased my abilities to work independently and as part of a team, provide feedback on others work, write reports and meet self-set deadlines. Overall it has been a very valuable experience and I would strongly advise students to take a similar opportunity if possible."

Andrew Kennedy, University of Bath: "Not only have I found out more about how I learn, but I have had a chance to develop my skills in a way which will hopefully aid other students in their learning. Throughout the project the staff and students from the four universities have provided valuable input which has helped shape the structure of the final site. Special thanks are due to Dr Jane White and Dr Emma Cliffe of the University of Bath, whose support and advice made the project possible."

Reflective comments from our student interns provide us with useful ideas to enhance the programme. Most notably, we acknowledge that a preliminary meeting, prior to the start of all projects, would be hugely beneficial to initiate and subsequently facilitate research support by the student community. The other issue that we should consider is placing more than one student in any participating HEI whilst maintaining a minimum of 4 participating HEI.

The success of our pilot strengthens the resolve to continue to develop the intern programme beyond the life of the National HE STEM Programme to create a community of students involved in the development of mathematics and statistics support nationally, to provide opportunities for students to engage in research into mathematics and statistics support in HEI and to develop and strengthen research collaborations in mathematics and statistics support within and between regional hubs.

Call for applications: Curriculum Innovation Travel Grants

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Grants supported by the HE Curriculum Innovation Fund, part of the Mathematical Sciences Strand of the National HE STEM Programme.

Summit recommendation:

Sharing good practice through an inter-university teacher exchange programme. For example, a lecturer may teach some classes or work in a maths support centre at another university. A lecturer may visit another university to observe and learn from some good practice, which could be brought back to the home university. Alternatively, a lecturer with some good practice to share might work in another university to establish use of that good practice there.

Although we decided the suggestion of staff teaching classes at other universities was too complex a model in the timescale, we have taken forward the spirit of this recommendation, facilitating visits to share good practice, through a travel grants scheme which is now available.

Curriculum Innovation Travel Grants are made available to lecturers to support travel between institutions and subsistence for one of the following reasons:

1. To pay for the travel of a speaker to offer a seminar on an innovative curriculum development used elsewhere that the institution is interested in taking up;
2. To pay for the travel of a member of staff to travel to observe an innovative curriculum development in practice that the institution is interested in taking up;
3. To pay for travel to bring together members of staff from two institutions to discuss collaboration on innovative curriculum development.

Bids to this fund must demonstrate a credible plan for transfer of practice or new innovation. In order to avoid money being spent on activities that produce no outcomes, grants will not be issued for highly speculative activities. Funding will not be available for attendance at conferences

Curriculum Innovation Travel Grants are available for the benefit of HEFCE- and HEFCW-funded institutions. In the case of type 1 and 2 grants the benefitting institution must be HEFCE- or HEFCW-funded. In the case of type 3 grants both partners must be HEFCE- or HEFCW-funded.

Grants will not support travel by private vehicle and receipts must be provided to claim.

Recipients of grants must write a short report (500-1000 words) on the seminar that was given, the practice that was observed or the collaboration that was planned. This must detail how practice will change as a result of the grant.

A simple application form is available via **www.mathstore.ac.uk/hestem**. To avoid complicated procedures, successful grant recipients will be asked to submit receipts with a standard expenses form.

N.B. subject to uptake and continued availability of funding, these travel grants will be available for the remainder of the National HE STEM Programme.

Jeff Waldock

Developing Graduate Skills in HE Mathematics Programmes

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Work supported by the HE Curriculum Innovation Fund, part of the National HE STEM Programme Mathematical Sciences Strand.

This project had three principal aims:

1. To capture examples of what is currently being done within Mathematics programmes in UK HEIs to address the development of graduate skills,
2. To provide an appraisal of what approaches appear to have been successful in developing these skills, and
3. To use this to make recommendations for the further development of these and other programmes of study that wish to encourage the development of graduate skills.

Although a number of graduate skills can be developed through extra-curricular activities, this project investigated curriculum-based approaches.

A set of 17 case studies from Mathematics departments at a range of UK HEIs were collected illustrating successful approaches to the development of graduate skills in different contexts and at different levels. These have been published in a booklet, and a workshop tour of five of the National HE STEM Programme Spoke regions has been carried out to publicise and disseminate the results. A subsequent call for small 'Developing Graduate Skills uptake programme' bids has led to three new projects, stimulated as a result of the case studies presented in this booklet.

Background

All stakeholders in Higher Education are increasingly aware of the importance attached to the additional skills students should be gaining at University, over and above their course-specific skills. Students are concerned, particularly with the large rises in tuition fees imminent, that courses will provide them with the full range of skills necessary to successfully gain graduate level employment. It is clear from University open days that prospective applicants are very aware of the new measures by which they can judge the performance both of Universities and of individual programmes, such as the National Student Survey, the Destination for Leavers from Higher Education survey of graduate employment and the various league tables, as published for example by the Guardian and the Times.

By August 2012, HEFCE expects all universities to publish Key Information Sets (KIS) for each of their courses on their institutional website, ***'providing prospective students with information about the HE experience that we know they find useful, in places we know they look for it'*** [1].

The KIS data will include student satisfaction metrics, learning and teaching activities and assessment methods, study hours, course accreditation, accommodation costs and graduate employment and salary outcomes.

In what is certain to be a very competitive student recruitment 'marketplace' there will be considerable importance attached by each university and by each course to presenting a successful profile against each of these measures. This is especially true at a time of high levels of graduate unemployment. The Guardian, for example, recently reported that ***"20% of recent graduates are unemployed – the highest proportion for a decade"*** [2] and ***"Almost half of all recent graduates believe their university education did not adequately equip them for the world of work"*** [3].

One immediate outcome has been the requirement from HEFCE that by August 31st 2010, all universities should publish an employability statement. This is described as ***"a short summary of what universities and colleges offer to their students to support their employability and their transition into employment and beyond"*** and is intended ***"to help prospective students make informed choices for entry in 2011-12"*** [4].

In addition, the HE Mathematics community has implicitly identified the importance of the skills element of the curriculum through the National Benchmark Statement [5]. Reflecting the diversity of provision to be found across the UK in the discipline, it says very little about subject content, only explicitly referring to calculus and linear algebra. General skill development, however, is prominent:

> ***"MSOR graduates will possess general study skills, particularly including the ability to learn independently, using a variety of media that might include books, learned journals, the internet and so on.***
>
> ***They will also be able to work independently with patience and persistence, pursuing the solution of a problem to its conclusion. They will have had the opportunity to develop general skills of time management and organisation. They will be adaptable, in particular displaying readiness to address new problems from new areas. They will be able to transfer knowledge from one context to another, to assess problems logically and to approach them analytically.***
>
> ***They will have highly developed skills of numeracy, including being thoroughly comfortable with numerate concepts and arguments in all stages of work. They will typically have general IT skills, such as word processing, the ability to use the internet and the ability to obtain information, always exercising these skills in a responsible way and taking care that sources are referred to appropriately.***
>
> ***They will also have general communication skills, typically including the ability to work in teams, to contribute to discussions, to write coherently and to communicate results clearly.***
>
> ***Where appropriate, they will have knowledge of ethical issues, including the need for sensitivity in handling data of a personal nature. All of these competencies enhance the general employability of MSOR graduates; see paragraphs 1.24 to 1.27."***

This of course raises the question – to what extent does the current curriculum in MSOR disciplines (and the learning, teaching and assessment strategies that deliver, support and assess it) incorporate these principles - and where it does, how successful is it? There is no objective measure of this, but a subjective measure comes from the National Student Survey, one section of which addresses the area of personal skills.

Table 1 gives the ranking of the Mathematical Sciences, as a discipline, against other subjects[1] on three relevant NSS questions over four years (2008-2011). An interactive view of the rankings for all 22 questions for Mathematics, for 2008-2011, is available at: **https://maths.shu.ac.uk/NSS/skills2.php**.

These data clearly suggest that students studying Mathematics perceive a problem in terms of their development of personal skills – at least, in relation to their own expectations. The consistency in this pattern over the last four years suggests further that there is a need to tackle the issue. Should we as a community be supporting each other in developing new approaches to skill development within Mathematics programmes and, if so, how?

[1] Those listed at Level 2 in the raw data returns from the survey. These data are available at http://www.unistats.com/

National Student Survey Question	2008 (52)	2009 (62)	2010 (63)	2011 (63)
Q19: The course has helped me present myself with confidence	66% 42nd	66% 42nd	70% 42nd	71% 42nd
Q20: My communication skills have improved.	66% 42nd	65% 42nd	70% 42nd	70% 42nd
Q21: As a result of the course, I feel confident in tackling unfamiliar problems.	75% 30th	77% 28th	77% 28th	79% 23rd

Table 1: Data for 'Mathematical Sciences' from the National Student Survey, Questions 19-21, averaged across all institutions reporting, and its rank within the 42 Level 2 subjects. The number in brackets after the year indicates the number of universities included in the average.

Implementation

There are significant barriers involved when seeking to modify Mathematics programmes to encourage the development of graduate skills. One is fundamentally philosophical, as some will wish to retain the pure, theoretical nature of their courses. Another is the practical difficulty of finding space for graduate skill development in a crowded curriculum.

This latter problem can be addressed – at least in part - through different approaches toward learning, teaching and assessment that allow skill development to take place alongside the development of the mathematical skills, and by encouraging students to take part in extra-curricular activities. Central to this is the need to increase student awareness of the wider purpose of each activity in developing their skills, and the value of doing so. In this regard, it is very important that students are able to recognise the part each activity plays in helping them towards the attributes expected of a graduate from their course. If so, they will be better able to see the benefit of the curricular strategies adopted, and hence better able to articulate their skill development when required. The introduction of the Higher Education Achievement Record, as recommended by the Burgess Report [6], will provide further incentive for this.

This project, building on an earlier informal liaison between staff from a number of HEIs with an interest in this area, began with a preliminary meeting of representatives of six departments to share ideas and to form a plan of action. It was decided to aim for short (two page) case studies, focussed closely on the development of individual graduate skills. A subsequent workshop was held at Sheffield Hallam University, in November 2010, at which provisional case studies were proposed and others identified. Staff at other HEIs who had published relevant work were contacted and asked to provide a case study to an agreed template.

Booklet, further development and sustainability

The final booklet contained 17 case studies and a commentary which provided background and context, and drew out some common themes arising from the case studies. The published booklet presents a series of short case studies, each focussed on specific graduate skills, providing examples of ways in which these have been successfully developed through curricular initiatives. There is a wide variety of work reported, both in terms of the skills developed as well as the type of courses and institutions involved. The expectation is therefore, that there will be something of interest and relevance to everyone who has a desire to make curricular changes aimed at improving the 'graduate' skill levels of their students.

Following publication of the booklet in April 2011, a workshop was held at five of the six HE STEM regions. The workshops were attended by some of the case study authors, who gave short presentations on their work, and other staff who had an interest in developing graduate skills. Presentations of this work were made at the CETL-MSOR Conferences in 2010 and 2011.

As well as a print run of 500, the booklet has been made available via the website at **http://maths.shu.ac.uk/msor/graduateskills/**. Up to 26/08/2011, 191 downloads of the document have been made from separate locations, representing 43 institutions in the UK, Australia and New Zealand.

A 'Developing Graduate Skills uptake programme' from the Mathematical Sciences HE Curriculum Innovation Fund offered a call for small bids specifically addressed at encouraging graduate skill development projects inspired by this set of case studies. In response to this call, three projects have been funded for 2011-12.

Discussion of findings

The requirement by HEFCE to publish employability statements has forced universities to articulate clearly exactly what it is they are providing students with in this regard, and to highlight the ways in which individual courses help students both to develop employability skills, and to recognise their importance. These have recently been reviewed by the Higher Education Academy [7]. One approach categorises these skills, identifying the activities within the curriculum that are involved. Course planners can then map these activities, showing progressive skill development across each level, and students can see how each activity is designed to build their skill set towards that expected of a graduate.

It is often the case that courses already include such activities, building employability skills alongside subject-specific technical skills, but without emphasising the fact. A light touch modification of a course, pulling together a 'skills map' to raise awareness of this may prove effective in itself, and may be used to identify a thread of employability activities throughout a course. An example is the Graduate Development Programme at the University of the West of England (*Case Study 11*).

It is very noticeable that nearly all – 14 of 17 - address generic employability skills, particularly communication and team working, reflecting the importance attached to these skills, and if allowance is made for the fact that career planning and PDP include elements such as self-awareness, the coverage is 100%.

The development of Career Management Skills (CMS) is the second most commonly addressed skill group, reflecting perhaps the increased desire both to raise students' awareness of the potential career paths they may follow, and the practical skills necessary to succeed in them. It is noticeable that nearly all of the case studies that deliver CMS do so throughout the programme, recognising that it takes time to build these skills to an appropriate level and that on its own an 'outduction' programme preparing students for transition to the world of work, while important, is not enough. It is also the most likely to be carried out through a separate, possibly ex-curricular, bolt-on delivery model and taught by non-mathematicians. It is important for mathematics students to understand their potential job market, however, and the development of CMS skills should take this into account. As with other employability skill development, this is therefore more likely to be successful if it takes place within the mathematics curriculum.

Relatively few of the case studies address the other two groups of skills. Reflection and action-planning, or PDP, is often seen as a completely separate activity from the core curriculum and consequently marginalised, being carried out infrequently, often under duress. An alternative approach starts with the view that in order to maximise achievement, it is important for a student to raise their levels of self-awareness, indentifying their strengths and weaknesses and having the capacity to develop a plan of action for addressing the latter. This way, the PDP process can be seen as supportive and beneficial and, provided that it is managed effectively by staff and carried out on a regular basis, can be very effective.

Work experience, as mentioned earlier, can make a significant difference to a student's chances of gaining graduate level employment. If graduate employability is of importance to course designers, it seems clear that the curriculum should embrace some form of work based, or work related, learning. There are a number of models to follow – and not all require a full sandwich year. There is clearly much to be gained from helping students recognise, and articulate, the skills they gain from all forms of work, including voluntary and casual work. Many universities now operate a skills award which recognises this, but it is possible for the course curriculum to also incorporate explicit recognition of the skills acquired in the workplace, wherever that may be.

With the introduction of the Higher Education Achievement Report in 2011-12, as recommended by the Burgess Report [6], it is expected that a much fuller description of all student achievement will be recorded, including wider verified achievements that will appear in section 6.1. All universities will need a system that can provide a verified record of relevant student achievements. Employability skills, assessed through the curriculum, could certainly form an important element of section 6.1 of the HEAR.

One final thought is that many of the case studies reported here emphasise that one vital element in success is that students perceive the activities, and the skills developed though engagement with them, as valuable. Obvious though it may be, it is worth remembering that much progress can be made by including students as equal partners in the learning process, and their input and feedback will improve the effectiveness of each initiative.

"Developing Graduate Skills in HE Mathematics Programmes - Case Studies of Successful Practice", ed. J Waldock, April 2011.
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HE STEM
Project in brief:

Career Mentoring Scheme for Maths Students

Employees and alumni acting as career mentors for current undergraduates. Project leader: Jeff Waldock, Sheffield Hallam. Supported by the North East Spoke.

Views of HE curriculum from ‘Young Researchers in Mathematics’

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Work completed as part of the HE Curriculum Innovation project, part of the Mathematical Sciences Strand of the National HE STEM Programme.

At the Young Researchers in Mathematics 2011 Conference [1] on 14th March 2011 at the University of Warwick I contributed a session, rather grandly titled ‘Innovation in mathematics HE teaching & learning’, which was peppered with periods of group discussion around teaching methods and graduate attributes. This paper is an account of that discussion, which I recorded with permission and made available online[1].

Young Researchers in Mathematics is an annual conference organised by and for postgraduate students and early career researchers, around 60 of whom attended my session. I didn’t collect institutional affiliations but you may have your own view on what sorts of institutions and types of educational environments such an audience may have experienced.

This paper presents an account of the responses given to questions I put to the audience followed by some discussion of these. This is not intended to be a representative sample or anything other than an interesting set of views from a particular audience, presented to provoke thought.

Account of the session

First, I asked the audience to “describe mathematics teaching at university”. Answers given were: chalk and talk; lots of lectures; someone stands at the front and talks; not interactive; small group tutorials with four or five students. I asked about assessment methods. The answers were exams and lots of example sheets for homework. I asked whether the homework involved short or long problems. The answer was these tend to be short, 3 or 4 problems per week. One audience member said sometimes in their first year there would be a 1.5 hour session in which students work in groups and at the end hand in a piece of work together. I asked whether they were ever given group work to take away or more in depth work and no examples were offered of either of these.

Next I asked the audience to “describe a first class student”. I received two types of answer here. The first was procedural: someone who can remember proofs and knows how to do exams well. The second was more conceptual: someone who can think for themselves and solve problems they weren’t taught how to solve. I asked if this meant “unseen problems, slightly outside of what they’ve seen” and the answer was yes.

Now I asked them to “describe a typical student”. The answers given were: very quiet in class; they wait for you to do something on the board then copy it down; they are

[1] Video of the session ‘Innovation in mathematics HE teaching & learning’ is available at: ***http://mathshe.wordpress.com/videos/***

used to doing standard techniques but aren't used to going beyond that and thinking for themselves; they're not very good at knowing when the standard techniques can be applied to other sorts of problems that don't look exactly like the one in lectures; they write things up sloppily so it's very easy for them to make mistakes and hard for them to tell where they went wrong.

The next question I asked was "what makes a good PhD student?" There were some answers here that appeared to be at least partially in jest and got laughs from the audience: going to conferences (we were at a conference); reading five papers a day; drinking lots of beer. More apparently serious answers were the qualities: willing to ask questions; ability to communicate with other mathematicians; motivation; enthusiasm; discipline; perseverance; being meticulous. I prompted with the question "what about working undirected, taking a piece of work away and working on it?" and was greeted with several yeses and the quality: "initiative".

I asked "how do you get onto a PhD?" The quick answer, "luck", got another laugh. I asked "are you better placed if you have a first class degree?" and was greeted with the answer: yes. At this point I said: "So first class students are good at regurgitating proofs and blah, blah, blah, and then when they become PhD students they're suddenly independent workers and self-motivating and...". I trailed off as several audience members started laughing.

Next I asked "what do your students do when they graduate?" The first answer, "make more money than we do", got a laugh. "Doing what?" I asked. The answers: finance; teaching; some become unemployed; some don't do anything necessarily relevant. I prompted with: "what about engineering and scientific research? Some of them might become statisticians. A lot of mathematicians seem to go into defence."

Finally I asked "what skills should a graduate of a mathematics degree be able to demonstrate?" The first answer was "numerical". I asked "what do you mean, basic numeracy?" and the answer was "you'd expect that of any graduate". Another suggested "analytic thinking skills". When asked what that means I suggested "thinking clearly and structuring your thoughts". One audience member asked "is that true of any graduate?"

This generated a list of attributes more specific to mathematics, which were: being able to make ideas more precise; dealing with abstraction; going between the specific example and the abstract case; being able to think in more than 3 dimensions; some mathematical methods, not necessarily *everything* they've learned; being able to construct mathematical models from real world problems; to understand 15% of what is at a maths conference; a good sense of what mathematics is, so they understand philosophy of mathematics, perhaps education and history of mathematics, as well as having studied a set of mathematical topics; to be aware of important unsolved problems; taking a problem, defining it properly and thinking it through; knowing how to approach a problem, knowing multiple approaches exists and knowing which is the best to try; being able to understand when you're wrong and when you're right and being able to explain why; being able to follow a logical argument and identify flaws; not needing someone to "babysit" them through hard problems; to understand when there is an optimal solution everyone can agree on and when it's a matter of opinion and different viewpoints arise.

Discussion

The discrepancy between the list of attributes of a 'typical' student and those expected of graduates is quite stark. The typical student is said to be quiet, unable to work on their own and unable to apply techniques in ways beyond what they have been shown. The graduate is expected to be able to move comfortably between specific and abstract cases, engage fully with the problem solving process and not need someone to "babysit" them through problems. Those who become PhD students must be motivated, independent workers who communicate well with other mathematicians.

The development from one stage to the other is said to take place in a teaching environment which consists mainly of a lecturer standing at the front and delivering a lecture by chalk and talk, with assessment by short problem exercise sheets and exams. My audience said they were not given in depth work as undergraduates and most did not work in groups. Quite how the independent problem solvers and able communicators are to be developed, except by chance, is not clear.

It is interesting to observe the two types of first class student identified. The first is the student who memorises proofs and knows how to do well in timed exams. The second is someone who can think for themselves and solve unseen problems. I would observe that the latter may be an aspiration of a mathematics education and the former is used as its proxy measure. I was told a first class degree would help someone get onto a PhD programme and that a capable PhD student is a motivated and disciplined independent researcher working with enthusiasm and perseverance on their own initiative. Whether the proxy is a good indicator of the desired measure is thus drawn out as a key question in understanding graduate attributes.

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Assessing student teams developing mathematical models applied to business and industrial mathematics

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Using case studies and group work, this project attempted to provide students with experience of business and industrial working practices and also to address the issue of how to solve practical mathematical problems. Students were organised into teams and tasked with solving a problem presented in the form of a real world industrial case study. Each group was assessed on their problem solving abilities, mathematical modelling skills and also on their team work and contribution to the group. Industrial partners were also invited to judge the final solutions presented by the group and feedback was offered, based on the 'real world' situation presented by the case studies.

Background and Rationale:

The methodology used to tackle the issue of problem solving was not a traditional academic route by examination or essay, but instead a pro-active approach through a team-based problem-solving format familiar to the world of business and industry. The idea for this approach was to prepare the students for the world of work and to highlight the way in which they will be expected to use their mathematical knowledge in their future careers. A vital part of this was exposure, understanding and experience of the development of mathematical models from concept to testing.

Throughout the module, seminars from guest speakers on a spectrum of mathematical applications used in industry would expand the 'real world/industrial' context to give students insight into the world of work and the way mathematics may be used in their jobs. The module task would assess the students' ability to do this. Industrial partners identified team working and problem solving as areas of vital importance so this project attempted to incorporate both into a series of tasks.

Students would be exposed to the various roles played within a team and so have the opportunity to assess their preferences, performance and capacity for changing role particularly in the context of developing mathematical models. This would provide valuable information to the student in understanding their strengths and weaknesses within group dynamics while also providing opportunity for reflection and change.

By the end of the module, the students would have had real experience of the type of roles played within teams, and be able to reflect upon how this dynamic directed the outcome of the task solution as well as how they responded to it. They would have been tested and assessed for a variety of business-like attributes not assessed by a standard academic module. This would help us produce more business-aware and business-ready graduates for the workplace.

Implementation:

The industrial speakers represented a range of different sections and included: DSTL, CMS intelligent banking, Manchester Medical Academic Health Sciences (NHS), IBM, an expert court case witness, IMA, and the Sellafield OR group. The industrial list was compiled from existing staff contacts and graduate alumni from the university. As well as describing what they do, which was almost exclusively mathematical modelling, the guest speakers also described the group structure of their companies, essentially project leaders managing small teams.

These talks were intended to provide an insight into working practices and demonstrate how the course structure and content reflects the industrial world. Topics covered by the talks included the career path, company profile and use of mathematics by the company. The work practices covered problem solving, communication and team-working thus providing the context, understanding and direct connection from the module to the world of work.

Two open-ended case studies were presented consecutively to student teams. The case study titles were:

1. What are the hours of daylight and darkness?
2. What is a variable APR mortgage?

The titles chosen were deliberately open-ended, and the mathematics required trigonometry and series respectively, typically to A-Level standard, so as to free the groups to follow their own direction for solution.

Students were arranged into teams of four members. Each member was given a specific role, and the team members and roles changed upon completion of each case study. The groups were left to organise themselves, arrange meetings and liaise with an academic adviser.

The four roles in each group were chair, secretary, task coordinator and technical coordinator. The groups worked on developing a mathematical model to answer the case study questions from concept, design and solution, through to testing. Groups were required to produce a minutes book, project plan, specification and final report which detailed their mathematical model. They were also required to give a group PowerPoint presentation for an audience of industrialists and academic staff, to which each team member contributed. Following these presentations the audience offered immediate feedback.

The academic adviser played a supportive role and was required only to respond to questions from the group. The academic adviser observed and noted the interaction between members of the groups, and how they adapted to being given roles and the change in roles between case studies. Both adviser and students were required to share reflective comments on this experience as part of a wider personal development process for the students.

As well as the academic advisers, the module coordinator had responsible for contacting, inviting and arranging the visits of guest speakers from business and industry, facilitating the meetings scheduled between the academic adviser and the student groups, making the students aware of the format of the deliverables with deadlines via the handbooks and the case studies, as well as organising the schedule for the student group presentations attended by the group of industrialists.

Evaluation

Evaluation took the form of feedback from the students and industrialists. Feedback from the students was required in the final report, in the presentation, and also in a separate reflection sheet. Feedback from the industrialists was given verbally.

From the students' final reports, there was significant positive feedback. They were asked to give an evaluation of the success of their project, identify what worked and went well and what did not work. The evaluation of the project covered the group dynamics as well as the deliverable outputs. The general response to this section was that they saw this project as an opportunity to problem-solve and provide their own solution, which was a "refreshing change" from the format in other modules.

However some negative feedback was present around group dynamics, in particular about group members that didn't contribute significantly and didn't come to pre-arranged meetings. One suggestion to resolve this might be to attempt to evenly distribute the students so each group had a balanced cross-section of ability and motivation, as the main problems came when two or more poorly motivated students resided in the same group.

In terms of the presentations, the students were very critical of themselves focusing in on what went wrong. They did not give balanced critiques which also highlighted the positives.

In the reflection sheets, students were asked to highlight key decisions that most influenced the direction of the assignment, which roles they preferred and how their involvement changed with the change in role. Although no common themes came out of these sheets as they reflected the personal involvement of each student; in writing down and having to reflect in this way, it is clear from the majority that the students were starting to reflect on their personal preferences within a group. It was also clear that their interaction changed with changing role, and each role was beneficial in developing them in different ways. It could be interesting in the future to see if more could be made of this, in terms of feeding into the student understanding their personal preferences, feeding into a personal development plan.

Feedback from the industrialists was given verbally and expressed the view that this type of project was immensely valuable in exposing the students to the type of work and working environment that would be expected of them in their future jobs. They said the case studies posed were challenging and that they were surprised by the high academic level achieved by the groups in the reports and presentations, and the variation in the directions taken by each group.

This work was presented at the Embedding Graduate Skills workshop in November 2010 at Sheffield Hallam University and at the CETL-MSOR Conference 2011. It was written up for the Developing Graduate Skills booklet [1].

Discussion

The principal goal, of exposing students to a problem-solving way of working akin to the work environment developing mathematical models, was successful. The realistic structure of the project task and the industry involvement through the seminar series and assessment made the task and the mathematics relevant to the students enabling them to see how their course is used in industry. This is one key reason why the approach was successful and appeared to make the module less 'academic' in the eyes of the students.

Another important success was in getting the students to think about how they worked in the reflection sheets and to start reflecting on their actions. This was successful in terms of the student response, in that they found it beneficial to themselves, although it was not directly assessed. As mentioned above, this type of activity could be used to feed into a personal development plan to identify the strengths and weaknesses of individuals in order for them to focus on such areas for growth.

A key lesson that was learned was that industrial involvement was paramount for success. Although not essential to the running of the module, the students responded to and respected the input and advice given by the company representatives over that given by the academics or careers staff. The company involvement made the content of the module real and relevant.

Also, the difficulty in obtaining a meaningful evaluation was highlighted. Feedback in the presentations and reports from the students focussed on the negatives of group members and of their own input. The students seemed unable to make a rounded assessment and present the positive aspects of their work.

Further development and sustainability

Future development will consider more carefully how to evaluate and adapt the wording used on feedback and reflection sheets to try to draw out more of the personal development that is taking place. It will be emphasised that a rounded critique rather than a negative criticism is required. More emphasis in the final report could be placed on the students' assessment of their personal and group development, perhaps with an additional section required on this.

An online peer assessment system such as WebPA [2] could be introduced as a possible alternative to assessing the group work element.

The students' overwhelming recommendation is for the module to be run again, and the university is committed to sustaining this as an essential embedded module within the degree programme for the foreseeable future.

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A Statistical Awareness Curriculum for STEM Employees

Project leader: Neville Davies, RSS Centre for Statistical Education, Plymouth University

For STEM employers and employees we will produce:

a) a web-based survey tool to audit the statistical skills of their workforce;

b) a curriculum, freely available via the RSSCSE web site, that can be taught to STEM employees using distance learning.

We will identify a range of topics under three headings related to what STEM employees should:

i. know about;

ii. be able to identify and critically evaluate;

iii. be able to fully understand or do.

Educational providers will be able to use the curriculum, specification, exemplars and resource links to create courses to deliver the material.

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London Metropolitan University Industrial Panel

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As part of the employer engagement theme within the National HE STEM Programme, the Institute of Mathematics and its Applications (IMA) was approached by the Head of Mathematics at London Metropolitan University to set up an industrial panel to review their maths degree and curriculum content in the context of meeting the needs of employers. The Industrial Panel was made up of an eclectic mix of people, from a range of backgrounds, experiences, age and gender. Employers involved were Corda, Unilever, NHS, Walsh Group and ex-Rolls Royce. All five employers were sent memory sticks of the maths degree curriculum content for review. The employers were then given a period of 6 to 8 weeks to review the curriculum and to fill out a review template to capture their thoughts and feedback.

A meeting with the Industrial Panel took place on 9th June 2011 at London Metropolitan University, where discussion and feedback was given to the Head of Maths, Dr Pargat Calay. Feedback from London Metropolitan University has been very positive. Dr Calay intends to work the feedback of the Industrial Panel into his curriculum development plans for 2011/12. He also intends to work with these employers on other employer-based curriculum projects.

A good practice booklet and DVD is in preparation to encourage further adoption of this process. This will showcase the experiences and process of working with employers in the context of reviewing the degree curriculum at London Metropolitan University.

Find out more about what the Institute of Mathematics and its Applications is doing as part of the the National HE STEM Programme via: http://www.ima.org.uk/activities/he_stem.cfm

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The University of Greenwich Maths Arcade

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Stretch and Support

I had been exercised for some time about how to stretch our most able students and those who have more prior mathematical knowledge, whilst at the same time support those with weaker backgrounds or who take a little longer to grasp the mathematical concepts we teach. When the opportunity came to put in a bid for University funding I devised a project designed to address these two ambitions.

The objectives included providing a weekly drop-in session where students could play various strategy board games and puzzles designed to hone and develop strategic thinking, alongside providing a safe place for them to obtain help on tutorial work. Having read John Mason et al's book on Mathematical Thinking for a review in Connections [1] I was aware that the ability to strategize does not always come easily to our students. Interestingly, and perhaps unexpectedly given the nature of the subject, the 2011 National Student Survey shows that mathematics students do not consider themselves to be good at problem solving [2]. Problem solving is one of the key employability attributes that we tell our students they will develop on a maths degree, so anything that can be done to aid and increase this is well worth doing.

The proposal was presented with the help of two, then second year, students to a University 'Dragons' Den' style panel. The panel were slightly sceptical but were won over, in part, by the students' enthusiasm and dramatic skills.

The project began in September 2010. Having researched a number of strategy games and puzzles a wide-ranging selection was assembled and leaflets were produced to advertise the "Maths Arcade". An initial lecture on "How to Think Mathematically" [3] grabbed the attention of new year students and helped to draw the first students in. Attendance over two terms was fairly constant with about 25-30 attending each week. This included a core group of about 15 who came most weeks, with others coming less regularly on different occasions.

Which Games?

The intention was not to start another Chess Club but rather to increase interaction between students and to get them talking about the games and the strategies involved rather than just enjoying playing competitively. There are a number of quite unusual board games on the market. One of the students' favourites so far is "Quarto" which contains playing pieces with four different attributes:

Fig 1 – Students playing Quarto at Maths Arcade

- Size – Tall and Short
- Colour – Light and Dark
- Fill – Hollow and Solid
- Shape – Round and Square

The aim is to be the player to complete a row of four containing the same attribute, for example four tall pieces regardless of colour, shape etc. What makes this game harder is that you do not choose which piece to play but your opponent chooses your piece for you. So a winning strategy might be to try to engineer a situation where your opponent is only left with pieces that give you a win. This is easier said than done as it is hard to keep track of all the different possibilities that might produce a win. No two games are the same and there are numerous ways that the students can investigate winning strategies.

Benefits to students

The benefits to the students were more varied than I had imagined. The weekly puzzle and board games stretched the most able but also provided new students who did not initially know each other with an occasion to socialise and mingle with their peers in an unthreatening situation. Maths students are often socially shy and this gave them an opportunity to form friendships in a safe environment. In particular students liked the opportunity to spend time and play these games with staff outside the classroom environment and beat them! A recent report by the HEA [4] says that "interacting with staff has been shown to have a powerful impact on learning, especially when it takes place outside of the classroom and responds to individual student needs."

Many students also made use of the tutorial help that was offered at the same time. They appreciated the fact that a number of staff were on hand to answer student queries and to set them in the right direction. Those who made use of this were often the students that would not have visited something branded as a "help session" because they do not like to acknowledge, even to themselves, that they are having difficulties with the material. Staff benefitted from being able to get to know a number of students in a relaxed and informal setting.

Student Feedback

As part of the Personal Development Planning, first year students were asked to write about a maths event in which they had participated and this could include the Maths Arcade. About two thirds of the cohort chose to comment on this. The only negative comments received were that one hour was not enough and it might be better after lectures rather than before. Positive comments included:

> ***"I like to go to the Maths Arcade because all of my tutors attend it"***

"The people who were once strangers to me when I first started [attending the Maths Arcade] are now some of my closest friends."

"I felt somewhat dubious about the word 'enjoyable' being used but I'm glad to say I was quickly proved wrong."

"[It is] a really good way to meet people and get to know the lecturers in a more informal environment."

"Attending Maths Arcade has been a major help for me this year and a huge factor in me having such successful and enjoyable studies."

"The benefits to the students were more varied than I had imagined. The weekly puzzle and board games stretched the most able but also provided new students who did not initially know each other with an occasion to socialise and mingle with their peers in an unthreatening situation."

Evaluation

The Maths Arcade has been particularly successful in attracting a large cross-section of maths students. Other extra-curricular activities such as the Maths Society have tended to interest a particular type of student whereas this appealed to students of all backgrounds and mathematical ability. The most rewarding aspect of the Maths Arcade is that our retention and progression rates, though always being good, were noticeably higher last year, which was appreciated by department and University senior management. Of course there are many other contributing factors but it is believed that the Maths Arcade played a substantial part in this.

National HE STEM Programme Support

Partway through last year the Maths Arcade obtained support from the National HE STEM Programme to extend and increase the provision. This has allowed us to run staff training sessions, purchase more games and extend our opening times to 3 hours per week instead of 1. This support has also enabled us to share our positive experiences with the University's School of Engineering.

During the first year the focus of the Maths Arcade was on social interaction. One extension that is being made this year is to encourage the students more explicitly to analyse these games mathematically. They could work out whether the person who moves first is more likely to win, examine how to force a winning position, see what happens when the rules are modified slightly, and even design their own strategy games. We also have some excellent computer programmers attending these sessions who are being encouraged to programme these games.

A report on the extension of the Maths Arcade will be presented at the end of the project in May.

Maths Arcades Elsewhere

The concept of a Maths Arcade was presented at Peter Rowlett's Ideas Exchange last May (see page 52). A number of people present were interested in running a similar provision. By the time you read this, National HE STEM Programme support will have been provided to set up Maths Arcades at several other universities. Training sessions and follow-up support will be provided to these Arcades.

Conclusions

This idea came about because of a perceived need to simultaneously stretch and support maths students. It involved taking a risk and trying something new and untested. Over the last twelve months we have adapted our provision in regard to student feedback and have had to make changes due to University and other constraints. This project has succeeded in ways that had not been foreseen and appears to have made a real difference to student engagement, retention and achievement which demonstrates the value of trying speculative ideas. I would encourage you to try a new idea. It may not work but it just might end up benefitting students and staff in many institutions.

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Appendix: List of games and puzzles

This list is an indication of the games available at the Maths Arcade. We tried to get a number of games that would be suitable for a group of students to play. We obtained some word games for students whose first language is not English. This list is not a definitive list as it was bought under constraints of time, money and University procurement policy. I would welcome suggestions for other items.

The classic games Backgammon, Chess, Draughts, Go, Reversi (Othello), as well as playing cards are also available at the Arcade but aren't included in the list opposite.

Abalone	2 player strategy game. The objective is to push six of the opponent's fourteen marbles off the edge of the hexagonal board following a set of simple rules.
Bananagrams	2-8 player word game. Using lettered tiles to spell words.
Blokus 3D/ Blockus Giant/ Blockus Trigon	2-4 player strategy game. Involves placing polyomino-based tiles onto a board to capture available space. Giant version is great for several students to play and watch.
Chaos	2 player strategy game. Involves stacking counters. Excellent but hard to learn.
Gambit	2 player strategy game. Involves sliding rows of coloured tiles.
Gobblet	2 player strategy game. Placing or moving already placed pieces, including larger pieces covering smaller ones, to make a row of four on a 4x4 grid.
Gygès	2 player strategy game. The object of the game is to move a piece to your opponent's last row. The catch is, no one owns the pieces.
Ingenious	1-4 player strategy game. Placing tiles on a board with a clever scoring system. Good for strategy
Joggle	2 player strategy game. Dice-based placement of marbles on a board. First to build a 6 marble rectangle wins.
Pentago	2 player strategy game. Placing coloured marbles on a 6x6 board, the quadrants of which can be rotated, to form five in a row.
Pylos	2 player strategy game. Placing marbles to form a pyramid according to simple rules. Whoever places the top marble wins.
Q-bitz	2-4 player game. Three rounds based on speed, chance and memory. Arranging cubes to make different patterns.
Quarto	Best game we bought! Described and pictured in the article.
Quirky	2-3 player strategy game. Uses coloured tokens to build equilateral triangles.
Quixo	2-4 player strategy game. Adding and shifting tokens to form five in a row.
Quorridor	2-4 player strategy game. Each player aims to move a pawn to the other side of the board but can place walls to obstruct their opponent. Good for programmers
Rubik's cube/ Hollow cube/ Sudoku cube	The classic puzzle and variants
Rubik's 360	Puzzle. Involves changing the position of six coloured balls in a central sphere to six coloured compartments in an outer sphere, by maneuvering them through a middle sphere that only has two holes.
Rubik's magic	Puzzle. Folding connected tiles to form a pattern.
Rumis	2-4 player strategy game. Involves placing blocks onto a board as part of a 3D structure to capture available space.
Rush Hour	1 or more player strategy game. The objective is to move a red car out of a six-by-six grid by moving the other vehicles out of its way.
Solomon's stones	2 player strategy game. A variant on Nim's game. Excellent for encouraging thinking and strategy and possibly not too difficult for the more able to program.
Sprocket	2-4 player strategy game. Using rotor pieces to create gears and lugs.
Square up	Like Sam Loyd's 15-puzzle. We have developed a program in Excel that produces a random 5x5 grid as the provided 4x4 is too easy. This now means that we can have 6 people play together with the program.
Stratum	2-4 player strategy game. Trying to cover the opponents' pieces by placing tiles.
Sudoku cards	2-5 player strategy game. Involves placing numbered cards according to sudoku rules.
Tantrix	1-4 player strategy game. Hexagonal tile-based placement. Good but hard to teach complexities of rules
Tower of Hanoi	The classic puzzle

MSOR connections
Student Insert

Nick Carpenter

The University of Greenwich Maths Arcade – student view

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Mathematical Thinking

When I first started my degree in Financial Mathematics at the University of Greenwich I felt excited, nervous and anxious about the challenges that lay ahead.

However I soon started attending the Maths Arcade and feel that this has been of enormous benefit to me both on an academic and social front. What attracted me initially was the title, which I thought seemed informal and friendly. My main purpose for attending was to make friends with like-minded mathematical students. As I do not 'live in' at university I realised that I might be at a disadvantage when establishing a friendship group. I also felt that as a first year it was important to engage in other aspects of uni life besides partying! Through the Maths Arcade I have benefitted by meeting others who are on the same wavelength as me. The opportunities to discuss, dissect and participate in stimulating and thought provoking maths games are something I have enjoyed immensely.

As well as socialising with my peers, the Maths Arcade also gives the opportunity to interact with the lecturers on a less formal level. This is in addition to tapping into the wealth of knowledge that they have about their subject. It also allows the lecturers the opportunity to interact with their students and gain an insight into their differing learning styles.

Every session at the Maths Arcade is different, as the discussions, games, people and ideas vary from week to week. Different ways of playing the games can be discussed and tried out to see what difference this makes. One of the many attributes, which I feel makes the University of Greenwich Maths Arcade unique, is that it is not just a place for 'maths geeks'. All maths students, whatever year or level they are at, are welcome to attend for fun, enjoyment, queries, banter and a light hearted approach to all aspects of mathematics.

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Development and integration of computer-aided assessment of discrete mathematics

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The principal aims of this project were to exploit and extend existing computer-aided assessments (CAA) in elementary discrete mathematics (sets, logic and graph theory) that form part of the Mathletics system. These questions were written in an extended form of Question Mark's Perception version 3 (P3) and exploit random parameters throughout, including very full feedback and diagrams, thereby generating thousands of rich questions that form an effective learning resource.

Although within P3 one can successfully encode algorithms that generate questions with specified characteristics, their answers and distracters based on mal-rules (incorrect but structured mistakes), it has not proved feasible to translate them to Perception version 5 (P5) as originally proposed. We therefore exploited an online web application, MathsE.G. developed under another project. This was designed to require little editing of original question content and needs no external software.

Building on this, the MathsE.G. application now hosts most of the 2000 original Mathletics questions developed using P3 and will be formally launched in September 2011. Delivery is via PCs or Macs using any browser (and in the future, mobile devices we hope). Moreover, the open source question coding in Javascript is relatively well future-proofed and hence portable to other CAA systems and ordinary web pages.

Background

The justification for this project is two-fold. First, graph theory typically appears within the curricula offered to most first or second year undergraduates in mathematics, computer science and electrical engineering. We are therefore talking about a large and increasing cohort (about 25,000 UCAS acceptance applicants in 2009).

Second, graph theory is often a completely new topic to most students, unless they have taken the D1 and possibly D2 modules within their A level maths optional modules. These modules are far less popular than statistics, or even mechanics, and are not even offered at many schools.

Given the above, it is highly desirable to be able to offer students computer-aided assessments in graph theory with the associated benefits of repeated practice, immediate feedback, no need for human marking, graphical presentation (very necessary in elementary graph theory), linking to other web resources etc. However, few CAA systems have much content in this area, preferring to focus on the perhaps more pressing needs of elementary numeracy, algebra and calculus.

Mathletics [1] does have at least some coverage of the basics and these are heavily used at Brunel University by our maths, foundations and electrical engineering students. It needed further development and this has now taken place.

Another justification is that, as they are rich questions employing MathML (for equations) and SVG (for diagrams) embedded within versatile JavaScript coding of algorithms and question display functionality, the graph theory questions offered a challenging test case for translation from Perception 3 to a more widely-adoptable system. Originally this was to have been Perception 5 but this proved difficult and too expensive for individual lecturers to adopt (the software licence was £5000 plus an annual fee of almost £3000).

Over and above that, it is important to consider the inhibitors to wider adoption by other institutions, despite the fact that the content itself is free and at least half UK institutions already have a Perception licence.

One of the reasons may be the prevalence of VLEs that often form an essential part of the institutions high-level teaching strategies. However the quiz engines in such VLEs are not sufficient to develop sound mathematics question styles that utilise not only random parameters within all parts of the question but also algorithms programmed behind the scenes that can respond sensibly with a variety of student inputs and offer targeted, and not just generic, feedback.

Another problem is that academics currently have to decide which system to use; this decision and setting up any of the systems requires effort and may be beyond the skills of many teachers/lecturers, especially if the CAA is required only for occasional or casual use.

We therefore decided to abandon translation into P5 in favour of our own web application, MathsE.G. that was being developed under a separate project (JISC/HEA's DeSTRESS project [2] on Statistics for Social Sciences). The graph theory questions formed a challenging test case for the later translation of most of the rest of Mathletics.

Implementation

Both of the items detailed above as justifications for the project have been addressed, although, as always, further work is possible and indeed, desirable.

The editing and development of the graph theory questions has been achieved by Zaczek. In particular she has prepared some 22 questions in total, comprising roughly equal numbers of questions from the following topics: vertex and edge sets, vertex degree, adjacency matrices and spanning trees (both Prim's and Kruskal's algorithms). All questions are very graphical. The spanning tree questions are completely new and offer very rich feedback, mimicking what a teacher would draw on the board at each step of the algorithm.

The other questions were edited where needed based on student feedback from 3 years' usage and analysis of the hundreds of CAA answer files produced and their exam scripts, see below. The new questions were trialed on the Brunel network with foundations and electrical engineering students this year and few problems were encountered. They will be supplemented by at least as many questions again in the above topics and related graph theory topics in November/December.

The second part of the project was to make the questions available more widely. In this the project was greatly assisted by the above-mentioned MathsE.G. development by Kamavi that effectively wraps the question content within a web application that manages delivery and provides supporting functions to the questions. This is quite technical. Suffice to say here that this new system was able to take the underlying question coding without much editing at all and present the questions in a Perception-independent application. All that the user requires is a PC or Mac using any browser (Internet Explorer, Chrome, Mozilla, Safari etc). This work was reported at the CETL-MSOR Conference 2011.

There were problems with the SVG components that are handled differently in Mozilla, but these were resolved using a different application: this is invisible to the user since the application will know what browser the user is using when the application is called. The Mathletics accessibility features (altering fonts/colours in text, equations and diagrams) have been preserved.

Obviously MathsE.G. is able to include the entire database of Mathletics questions/feedback screens that span GCSE to A level to undergraduate maths and stats (some 2000 questions in all, each giving thousands or millions of realizations). The graph theory questions provided a stringent test case for the new technology.

The issue of mobile devices is as yet unresolved; the problem is that mobile browsers do not support Java Runtime Environment (JRE) and hence cannot handle the applet we have been using to display equations. This may not be a problem in the future, given that many users are discussing this on web fora. In the meantime, a work-around is being sought. However, it is likely that future editing will use a browser-native system such as MathJax or JSMath that does not require applets.

Evaluation

We have not yet evaluated the new MathsE.G. interface, apart from (generally positive) informal feedback on the trial web application[1]. Naturally further evaluation will take place once the full version (that includes search facilities and student and teacher interfaces) is mounted in autumn 2011.

In contrast, the evaluation of the graph theory question developed as part of this project has been carried out rather fully, as part of Zaczek's PhD studies. The objectives here are to understand students perceptions of their learning (as evidenced by their committee reports – see below) and how this compares with the actuality of their learning (as

[1] *Trial web application available at: http://www.mathcentre.ac.uk:8081/mathseg/*

evidenced by assessment via CAA and the traditional end-of-module unseen written exam).

For the last three years, CAA for Graph Theory within Mathletics has been included in the coursework for the Discrete Mathematics module for about 100 Foundations of IT (FoIT) students, (together comprising 20% of the module). Thus 5 tests are run, with repeats allowed and group work sanctioned; this moves the focus away from summative assessment to formative assessment and structured discussion sessions indicate that students correctly view the tests as learning resources in their own right. Thus the main sources of evaluation (apart from informal feedback and casual observation of students in PC lab classes) are:

Committee reports comprising all students (these replace traditional student feedback questionnaires for all FoIT modules and are a Study Skills module exercise in running committees and producing minutes on the students' views of all their modules):

A simple textual analysis of the minutes was carried out. Students acknowledged that feedback is being provided by the CAA and that it provided good practice for exam-type questions. No negative comments applied to the CAA itself, but two committees mentioned the spacing of the deadlines as being a problem.

Analysis of answer files (all students):

A detailed analysis of the answer files comprising over 300 tests delivering about 1900 question is beyond the scope of this report. However it is worth mentioning that the discrimination of all questions was satisfactory indicating that the questions were free from errors and clear enough for students to understand unambiguously what was required. Only 7 questions could be considered as being too hard (none were too easy), and these were either multi-step questions or required students to master precise mathematical definitions; so they were valid questions.

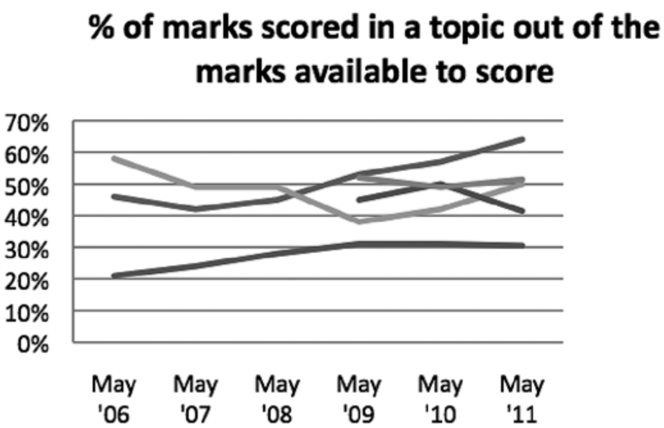

Fig 1 – Exam average marks for Number Systems, Graph Theory (from '09), Logic, Linear Programming (from '09) and Sets in descending order of May '11 marks.

Analysis of exam scripts (all students):

Zaczek and Greenhow [3] show exam average marks for each of the 5 topics comprising the FoIT Discrete Maths module and this is extended to the current year below. That paper also discusses topic indicators for several of the topics but none have been identified or used for Graph Theory; an issue for future studies.

The analysis of exam scripts also showed that the least popular topics often had the best average marks; this seems to be due to the chronology of the teaching schedule. Graph theory was taught at the end of the module and it is arguable that only good students were still engaged then. This is interesting but impacts only obliquely on the question of the efficacy of the CAA component of this topic.

Outcomes

Key findings are:

- Given a sufficiently rich graphical CAA system, effective graph theory questions can be written and delivered
- Evaluation techniques used as part of Zaczek's PhD studies can be applied to the graph theory questions
- MathsE.G. forms an excellent delivery mechanism for the graph theory questions, despite their complexity and rich content including MathML and SVG. This will be launched in autumn 2011.

Goals achieved:

- The goal of developing graph theory questions has been met in full
- Supporting functions for these questions have been written
- The goal of translating and delivering them via a flexible interface has been met in full
- The subsidiary goal of delivery via mobile devices has hit a problem and is not yet resolved, but the precise nature of the problem is now known.

Further development and sustainability:

Future development will naturally expand to provide CAA for other topics within elementary Graph Theory e.g. Dijkstra's algorithm. Other areas of discrete mathematics certainly should include work on Sets, as indicated in Fig 1 where it is a persistently difficult topic for students.

Sustainability will be assured by the development and dissemination of MathsE.G. Indeed we are planning not only to include all of the Mathletics questions in this interface, but also questions from other systems such as UWE's Dewis [4] and Newcastle's Numbas [5].

Dissemination will not happen automatically but since Maths E.G. will be hosted by MathCentre it will therefore reach other HE institutions. However, much of the material

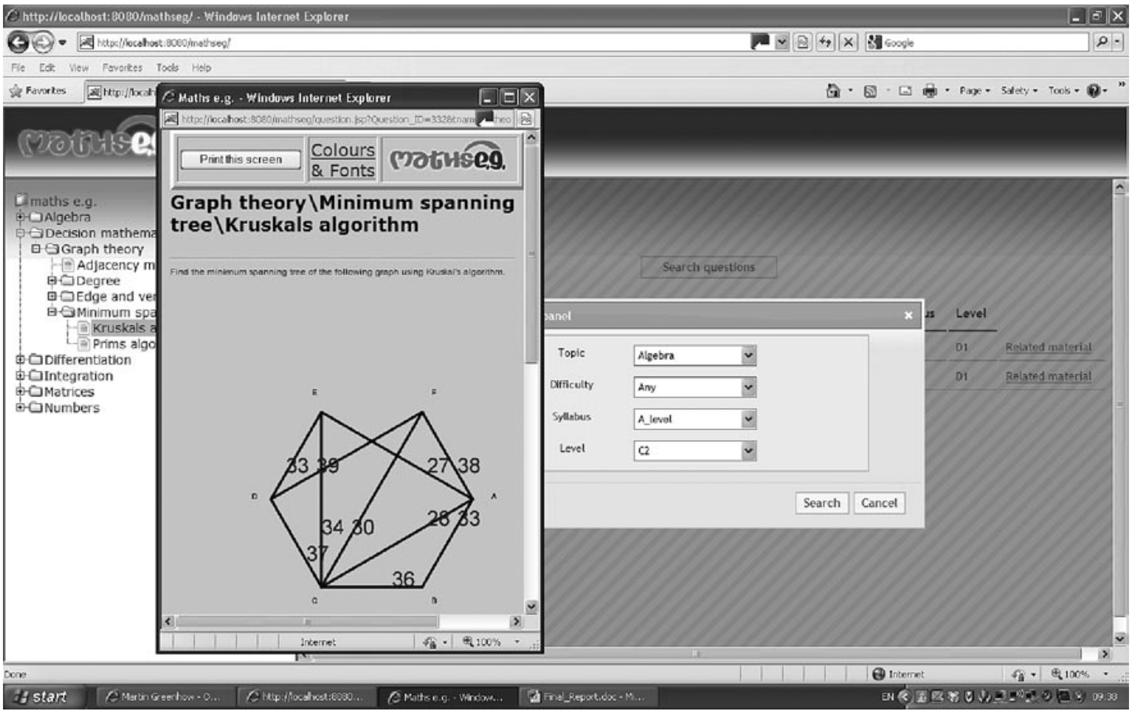

Fig 2 – The MathsE.G. trial interface showing a graph theory question and the search facility

is also pertinent to FE, schools and in-service training for e.g. health professionals who may take up the numeracy and basic algebra parts of the database. Another target group might be PGCE students who all must pass a national numeracy test. The beauty of MathsE.G. is its flexibility; students may select what they want, and staff will be able to tailor assessments as they wish for their own students. Beyond that we anticipate that the very full feedback screens will form an effective learning resource for students and staff, who might use them as examples on which to base lecture notes or assessments (including exams).

Maths E.G. can be accessed through mathcentre via **http://www.mathcentre.ac.uk:8081/mathseg/**

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Alun Owen, Peter Samuels, Michèle Wrightham, Bernadette Leckenby and Mollie Gilchrist

A Pilot for a Shared Online Statistics Advisory Service

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Work supported by the HE Curriculum Innovation Fund, part of the National HE STEM Programme Mathematical Sciences Strand.

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Background

Statistics Advisory Services (SASs) have recently been established at several UK HE institutions [1], offering statistics help and advice to students undertaking a final year undergraduate or Masters project or engaged in postgraduate research. A SAS is appointments based and is normally provided in addition to drop-in support offered via a mathematics support centre. Typically it offers statistics advice in relation to aspects of study design, questionnaire design, data analysis, use of statistics software, and the interpretation and reporting of results.

However, not all UK HE institutions currently offer this type of SAS, possibly due to a lack of suitably experienced personnel or financial resources. In response to this, a National HE STEM Programme pilot project operated an online SAS shared between several HE institutions.

The objectives of the project were to identify the practical and pedagogical issues associated with sharing an online SAS resource, and to elicit the opinions of students using the service in order to understand their expectations and experience of using this type of online support.

Implementation

The project facilitated a total of 68 appointments taken up by 46 students from the three partner institutions (Birmingham City University, De Montfort University and the University of Sunderland). A statistics advisor was employed as part of the project, working remotely from her home.

The students met with the statistics advisor using an Elluminate[1] online learning space/web meeting tool. The Elluminate learning space was provided by Loughborough University which has recently adopted Elluminate as its primary online learning space. For the last two years this tool has been used to provide online access to the SAS for Loughborough University students who are studying or researching part-time or via distance learning.

Evaluation and discussion

Students' opinions were sought via a follow up online questionnaire. In addition, more in depth opinions were gathered from three students via follow up case study interviews.

The over-riding picture that emerged from the study was that the students found Elluminate easy to use and both the students and the statistics advisor felt that this tool has many advantages for use in the provision of this type of online support, particularly in view of its easy to use application sharing facility. This means that statistical software such as SPSS or Minitab, or indeed Excel, can be shared simultaneously by both the student and the statistics advisor. This allows the statistics advisor to see the student's data during the appointment.

However, many students did experience some technological issues during their appointments. These were reported across all institutions and related mainly to either difficulties with the audio or to connectivity problems. The occurrence of both of these problems does, however, depend very much on the computer hardware and type of connection being used by the student. These problems could be removed to a large extent if the student had access to a PC at their host institution, which was known to have a good wired internet connection and a headset that functioned correctly using Elluminate.

Some students also displayed a lack of confidence with using this type of online tool. This may be partly due to a lack of previous experience with the technology. Where the student's first language was not English, communication difficulties may also have been a contributory factor to this lack of confidence. Some of these problems with lack of confidence can be overcome to some extent by giving one-to-one instruction on using Elluminate before their online appointment. Note that all students were given written instructions on using Elluminate prior to their appointment and also pointed to a video providing further instruction if required. Some of these students did also receive one-to-one instruction in the use of Elluminate by a local contact at the host institution.

If such a shared SAS resource is being considered in the future then it seems clear from this pilot that a local contact at each partner institution forms a vital component of the success of the service. This same person could also provide a screening function, similar to that undertaken at some of the host institutions during this pilot, to ensure that their needs could be satisfied via the online SAS.

In terms of the pedagogical value of the service to the students, 85% of the students completing the survey reported that they were able to obtain help with "Most" or "All" of their statistics problems and the remaining 15% reported that they were able to obtain help with "Some" of their statistics problems. Furthermore, all but one student in the survey considered their overall experience of the service to be "Good" or "Very Good" and these same students said that they would use this service in the future if there was no alternative source of support and would also recommend this service to a friend.

Further work and sustainability

This pilot study has demonstrated that an online SAS is able to offer a practical alternative to an institution specific face-to-face SAS if suitably experienced staff are not available locally. In addition, it has shown that is feasible for this type of service to be shared by a number of institutions and that this might offer a viable option in order to share the financial costs of providing such a service.

This work was reported at the CETL-MSOR Conference 2011. A full report will be available to disseminate what was learned in conducting this pilot, with details of the implementation, case studies from the institutions involved and recommendations for running an online SAS service.

We believe that this type of shared service would offer universities a viable alternative means of providing a SAS without incurring the financial costs of resourcing a SAS solely dedicated to their own institution. Given the new climate of student access to information relating to learning support and the proposals set out in the UK Government's Higher Education White Paper on "Students at the Heart of the System" [2], it would seem sensible to further consider this type of support provision and we look forward to being able to take this idea forward.

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[1] *Note that Elluminate is now known as Blackboard Collaborate (see www.elluminate.com)*

Joel Feinstein and Peter Rowlett

Media Enhanced Teaching and Learning

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Experience has shown that one of the most successful ways to deliver mathematics lectures is by working through handwritten notes and examples. I (in this article, 'I' refers to Joel Feinstein) am interested in ways that technology can enhance this process. Tablet PCs offer a modern approach to chalk and talk that can replicate most of the best features of writing on a board while allowing improved delivery, such as being able to annotate existing notes and insert graphics such as circles and lines into diagrams. Using a tablet PC opens up new opportunities, such as integrating software into lectures and recording onscreen content as video with synchronised sound for later viewing and distribution.

Since 2006-7, I have used a tablet PC and a data projector to display slides which I annotate during classes. In 2007-8, I also made audio recordings (podcasts) of all of my classes. For more details concerning my early use of a tablet PC and audio recordings (podcasts), see [1].

Since 2009-10 I have been recording screencasts of my classes (movies of everything that is displayed on the screen during my classes, with synchronized sound). Along with other resources, I make the annotated slides and recordings from classes available to the students from the module web pages as soon as possible after each class. Classes which have been recorded in previous years are not recorded again, but the earlier recordings are made available to the students. For more details concerning my implementation of using a tablet PC to produce screencasts, see [2].

Many of the resulting screencasts are suitable for publication as open educational resources. I am making resources available directly through my blog and/or through several of the University of Nottingham's channels [3].

Feedback from students is extremely positive. Many of the positive features identified in student feedback are as in [1]. However, the screencasts appear to be even more popular than the audio recordings were. Selected specific feedback:

- Students find it very helpful to have access to the annotated slides and the recordings shortly after each class. In particular, if they suspect that there may be a mistake in their written notes, they can immediately check the annotated slides online in order to avoid wasting time.
- Students who miss classes, for example through illness, strongly appreciate the opportunity to have access to the annotated slides and the recordings at times convenient to themselves. They find this far superior to having only a copy of the notes.

- Students appreciate having the opportunity to revisit portions of the classes where they feel that they may have missed some useful spoken explanation. This is especially helpful for students who are not native English speakers.
- Students find large and clear writing helpful. This makes using the tablet particularly effective in rooms with large data projection screens. This has benefits for students with dyslexia.

"If you are prepared to invest the effort required these methods of teaching are highly rewarding. Your students will strongly appreciate the provision, and you will be able to produce high-quality learning materials which can be made available to a wider audience."

The following issues are worth considering, however.

- A data projector can only display one screen at a time. If necessary you can scroll back through the preceding material, or display the slides at a smaller scale. Even so, the amount of material visible at one time is far less than there would be on a good set of blackboards/whiteboards.
- The microphone generally only picks up the voice of the teacher, and not the students' responses and questions. It is best to repeat what the students say both for the sake of the recording, and also for other students.
- While many students appreciate and take advantage of the materials available in order to improve their understanding, other students may stop attending classes, and may fall behind. As a result, some students may end up doing worse than they would have done if less material had been made available. One way to address this problem may be to have appropriate class tests or assessed coursework to discourage students from falling too far behind.

If you are prepared to invest the effort required these methods of teaching are highly rewarding. Your students will strongly appreciate the provision, and you will be able to produce high-quality learning materials which can be made available to a wider audience.

At the University of Nottingham, the popularity and success of my use of technology in teaching mathematics inspired several other members of staff in the School of Mathematical Sciences to use tablet PC's in their own teaching and to record screencasts. Now a group of colleagues in a number of disciplines have begun using Camtasia to record video materials to support their teaching. The University of Nottingham Media Enhanced Teaching and Learning (METAL) project, which Claire Chambers and I lead, aims to build and support the growing community of staff involved in creating audio visual teaching material by distributing 100 Camtasia licenses and running staff development workshops on this technology to disseminate ideas concerning good practice and to discuss methodologies. Recordings of sessions from the METAL workshops are available via my blog [4].

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The following article is based on a METAL workshop presentation and looks at lecture capture technologies, how they are used and their effectiveness.

Peter Rowlett

Lecture capture technology – technically possible, but can it be used effectively?

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Work completed as part of the HE Curriculum Innovation project, part of the Mathematical Sciences Strand of the National HE STEM Programme.

Technology in the Curriculum

It is now fairly straightforward to capture live lecture content for later distribution. This may be audio [1], perhaps linked to PowerPoint slides [2], or video recordings [3]-[10]. Preston et al. [8] notice in the literature a pattern of universities introducing these technologies to "adapt to the changing needs of their students". That students are positive about this technology (for a typical example, see [6]) is worth noting but, as Preston et al. observe academic staff struggling with the technology, it is important to ask what one aims to achieve and whether this technology can be effective against those aims.

For example, Cramer et al. [4] found that 73% of their students agreed that their use of a lecture capture system "would enhance their learning", 54% agreed it "would improve their grades" and 93% agreed it "should be offered in other courses" (pp. 111-112). However, they found "no significant relation between expected grade and both the number of accesses and duration" (p. 112). Perhaps, then, student positivity is not sufficient to recommend wider use of the technology.

It is also important to consider a possible negative effect on student learning. If the technology improves learning it may be judged a success (probably this is an aim), or if it makes no difference it may be a waste of time (although it may improve student enjoyment, and therefore feedback, retention, etc.). If instead the technology causes some unseen disadvantage to some students then that makes it potentially damaging.

What do lecturers intend?

Loch [11] remarks that "new technology is often used the same way old technology was used, and not to its full potential, because of lack of knowledge and comfort of familiarity on the user's part" (p. 236), suggesting a default mimicking of the replaced method without considering whether this approach is most effective. It is important to define why a new technology is being considered and how such technology is used, so a judgement can be made about whether that technology can be effective against the aims of its introduction.

Such aims may be general, perhaps to help students "achieve better results" or to make it "easier for students to learn" [9], or may be specific to a single aspect of student behaviour, such as solving tutorial problems [3], "improving student note taking and note use" [5] or to establish a "baseline of knowledge" ahead of lectures [2].

How do students use these resources?

Technology is often not used in a way that was predicted by its initiator. For example, Grabe and Christopherson [5] were surprised at the low rate of use of recordings to review lecture content in their research. They speculate that reviewing written notes is far quicker, so more efficient, than listening to the lecture (p. 7). Brindley et al. [3] made content available for mobile devices but found that 83% of students "accessed the videos via their home PC, with only a small number using a mobile device" (p. 5). When planning to use a new technology it is useful to consult such studies of what students typically do with resources.

White [1] and Yoon and Sneddon [10] found students using recordings to supplement lectures they had attended. White found that students "do not expect to understand the lecture completely when they first hear it" so review "difficult material several times" (p. 25). Yoon and Sneddon report this as the "most common reason for viewing recorded lectures", with "a secondary emphasis" on revision for tests and exams (p. 439). These findings are in line with those reasons found by Gosper et al. [6] in a survey of students across four universities in Australia.

Are these methods effective?

Let us say, for the sake of argument, that assessment performance is a good measure of 'success' in learning. Yoon and Sneddon [10] found that "the specific intentional use of recorded lectures as a back up resource to go over something that the student did not understand during the live lecture" was "weakly significantly associated with higher grades" (pp. 441-2).

von Konsky, Irvins and Gribble [9] say that students "may feel that listening to complex material multiple times will allow it to 'sink in'". Yoon and Sneddon found that "watching recorded lectures more than once", a practice observed also by White [1] and Gosper, et al [6], was not associated with grade (p. 442).

McFarlin [2] found that introducing an online component to a lecture course "was associated with a significant improvement in student grade performance" (p. 90). However, not all studies find similar results, for example von Konsky, Irvins and Gribble [9] found their system, while "a useful learning strategy for some", was "not required to achieve a successful academic outcome", "did not guarantee that learning would always take place" and "could not be used to predict the level of scholastic achievement." Stanca [12] highlights the problem that the students using the recordings may be those more inclined to do well in any case, meaning any difference in assessment performance may be inherent in providing some new learning opportunity. In that case, we must ask whether the students who are using the new opportunity would learn equally well from an alternative, and whether the students who are not engaging with the new opportunity are being disadvantaged more than they would by an alternative offering.

Many studies report usage; perhaps the nature of the technology makes this an easy to access metric. Of course, this approach can have measurement problems (some are discussed in [1]). In addition, Yoon and Sneddon [10] report "merely watching recorded lectures was not significantly associated with grades" (p. 441). von Konsky, Irvins and Gribble [9] note that, just as "physical presence during a lecture does not mean that a student is paying attention, synthesising new information in the context of prior understanding, or developing insights that will foster learning", so "playing a lecture recording does not necessarily mean that learning will take place". They warn that "sitting in a room while a recording is playing, perhaps while simultaneously engaged in other activities, may lead some students to the incorrect view that learning must be taking place".

Is there an effect on attendance?

Preston et al. [8], quoted an academic interviewee:

> ***"I think it can help [students] to justify not coming to lectures. They think, 'it's OK not to go, I'll listen to the iLecture later.' I fear later never comes or comes too late and they cram for assessment."***

Stanca [12] suggests links between attendance and measurable performance may be found to be correlated (see, for example, [13]) simply because the students more likely to do well are also more likely to engage more fully (p. 252). Still, does the availability of recordings have an effect on attendance?

Several papers ([1], [4], [5], [7], [9]) find no link between availability of recordings and absenteeism. Yoon and Sneddon [10] found most respondents "attended the majority of those live lectures for which recorded lectures were available... and caught up with some of the lectures they had missed by watching the recorded lecture" (p. 438).

Preston et al. say lecture capture systems may have acted to focus attention of the existing trend of decreasing student attendance. They found that 55% of 155 academics "felt the [lecture capture technologies] had resulted in decreased lecture attendance". They listed lecturers' concerns about the impact on students, "including their ability to keep up with crowded curricula, engagement with the content and the continuity of lectures and tutorials". They note that "this concern was not shared by the students in the study", finding 68.3% of 331 students "agreed or strongly agreed with the statement 'I could learn just as well using [lecture recordings] as face to face'." Just 5 out of 155 academics agreed with this statement. Regardless of who is correct, this is clearly a discord between staff and student expectations about lectures and learning.

On assessment-driven working, White [1] and Brindley et al. [3] both reported large increases in downloads corresponding to exams, leading to concern about cramming.

Some respondents on one of the courses studied by Yoon and Sneddon "still missed 10% of lectures completely, by neither attending the live lecture nor viewing its recording" (p. 438). Considering the reason for this, they note that 40% of respondents from that course "intentionally missed some live lectures due to the availability of recorded lectures" and 52% "said they had intended to watch more recorded lectures but did not get around to it" (p. 438). They suggest "the availability of recorded lectures may in fact contribute to students watching fewer lectures" (p. 438).

How might lectures be changed by this technology?

One problem with recordings was identified as far back as 1968 by McConnell [14]. Students "clearly preferred" being in a live lecture, whether this was small or large group, or taught by an experienced or inexperienced teacher, to watching a recording of an experienced teacher giving the session (p. 479). The reason given was that the recording lacked "direct question-and-answer and classroom discussion" (p. 479).

The studies reported above may differ in level of interaction. For example, while White [1] found "no significant association between attendance and download frequency", he used a personal response system in classes and assigned "points" for answering questions with this system in lectures (p. 27). This may have provided a greater level of interaction and strong incentive to attend. Yoon and Sneddon [10] note that the lectures in their study, for which decreased student attendance was observed, were "largely non-interactive". They suggest that the recording "mimicked the lack of interaction in the lectures" which meant a faithful recording of the lecture was an appropriate replacement. Further, they hypothesize that a high level of interaction and participation would mean the recording could only supplement, and not replace, the live lecture (p. 443). The question of attendance then becomes: what are students getting out of lectures? Some answers are given in [6], [7] and [15].

Preston et al. [8], report "a range of lecturers' responses to changing attendance patterns... including restructuring units to replace lectures with more interactive tutorials or workshops, replacing some face to face lectures with additional tutorials and providing the lecture materials as pre-recordings. In contrast, one interviewee had introduced roll taking to encourage students to attend lectures." They note that the introduction of this technology could act as "the catalyst for change" of "the whole teaching and learning context", but report that of the academics in their study: "43.2% of staff respondents had not changed their lecturing style; 36.7% had not changed what they do in their lectures; 74.9% had not changed the structure of their unit."

Discussion

Lecture capture technology clearly has some potential for having a positive effect on student learning. As seems usual for technology intervention, however, it seems that the positive benefit is observed when the technology introduction is associated with some change in the course delivery or design. The studies reported here are usually small scale, and this sort of curriculum intervention is naturally going to be hugely affected by contextual effects such as institution, discipline, method of instruction and instructor.

Availability of recordings may lead to cramming for assessments, but it seems reasonable to suggest that wholesale re-watching of lectures is not the most effective form of exam revision. Worse, it is possible some students are skipping lectures and watching them for the first time just before the exam, or not at all. Yoon and Sneddon identified a positive behaviour as: attending live lectures and using the recording shortly after the lecture to re-examine any parts they had not understood. After all, White reported that students do not expect to understand everything the first time they hear it.

If we would like to allow students to re-watch lectures as a reinforcement tool shortly after attending the live lecture or to catch up on lectures missed, but not for re-watching over and over or for revision, there may be some merit in making recordings available for only a short period[1]. Brindley et al. released recordings of particular parts of the material and this approach may be a more appropriate alternative.

Instead, it might be fruitful to provide students with a summary of the findings given in the literature to allow them to make an informed decision about the best way to make use of this new technology. Yoon and Sneddon give an example of such advice (p. 444).

This technology seems to cast a light on the existing problem of non-attendance. A punitive approach to non-attendance – taking a register, or withholding recordings from students without a good reason for non-attendance – seems ill-advised. Instead, we might examine what lectures can deliver and how course delivery might be adapted to improve learning in light of the opportunity offered by using this new technology.

[1]This was suggested to me by David Hodge when I gave a talk on this topic at the Media Enhanced Teaching and Learning workshop on 27th May 2011 at the University of Nottingham.

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Methods to produce flexible and accessible learning resources in mathematics

Project leaders: Emma Cliffe and Jane White, University of Bath

A curriculum barrier for students with disabilities is the delivery of mathematical learning resources such as lecture notes, problem and solution sheets in inaccessible formats. The current practise of repeatedly re-typesetting notes to produce particular formats is expensive in the long run. We will develop methods, instructions and examples by which a single master copy may be used to automatically produce a variety of formats. Thus all resources are updated from a master enabling departments to make proactive adjustments. The methods will be appropriate for use by individual lecturers/departments with access to a small range of mathematical/assistive technologies.

This project is supported by the Mathematical Sciences HE Curriculum Innovation Project, part of the National HE STEM Programme.

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Background

The volume of instructional mathematical videos now on the internet is bewilderingly large (a Google search for video tutorials on ODEs produced 785,000 results). Confronted with the huge unstructured collection of such videos, it is hard for students to find what they are looking for and then to know whether what they have found is relevant and reliable.

This is a small-scale, proof-of-concept pilot project, taking the first steps to create an online portal giving searchable access to a selection of recommended mathematics video tutorials, and to illustrate the website's functionality by populating it with the resources for a sample topic.

This pilot will focus on a single limited topic (first-order ordinary differential equations) and organise the available resources into a structured and annotated repository that is quickly accessible through a user-friendly interface. It will target first-year undergraduates studying a number of STEM disciplines.

The site will be made ready for testing by volunteer staff and students who will be asked to provide feedback on its effectiveness.

Summary of progress to date

1. Designs for the presentation and structure of the web site have been explored;
2. Various content management systems have been tried;
3. PHP and MySQL training has taken place;
4. Technical and pedagogic criteria for evaluating mathematical video resources have been established and a rating system devised;
5. A comprehensive search for online video material related to first-order differential equations has been carried out and the resources have been evaluated;
6. Contact has been made with a team at Leicester [1] who are doing work which has elements in common with this project.

The gathering and evaluation of online video resources on the specific topic of first-order differential equations has been fairly exhaustively carried out. I have been assisted in this research by members of the **sigma** maths support team during quiet periods of their tutorial duties. The technical, mathematical and pedagogical quality of much of what we have found is poor and only a limited selection of available resources meet the standards expected for the seal of approval as 'recommended' learning material.

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Good Practice on Inclusive Curricula in the Mathematical Sciences

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Background

Inclusive curriculum practice refers to "the process of developing, designing and refining programmes of study to minimise the barriers that students may face in accessing the curriculum" (Higher Education Academy [1]). In addition to reacting to the needs of individual students through reasonable adjustments, potential barriers should be anticipated and resolved in a proactive manner. Both aspects are part of the legal requirement [2]. A focus on the core requirements of the course allows potential barriers to be identified, so that course delivery can be redesigned to remove or reduce those barriers.

Courses with substantial mathematical content pose specific accessibility challenges beyond those usually considered in generic inclusive curricula good practice advice (see for example the series of articles in MSOR Connections [3]). The Mathematics, Statistics and OR (MSOR) Access Working and Interest Group (AccessMSOR WG) [3], of which the author is Chair, brings together expertise and interest in issues surrounding the support of disabled students in MSOR subjects. An AccessMSOR WG workshop on inclusive curricula in MSOR took place with support from the National HE STEM Programme in February 2011. Following this, group members and workshop attendees were invited to submit case studies or reports relevant to the theme.

The resultant guide, 'Good Practice on Inclusive Curricula in the Mathematical Sciences', seeks to complement and extend, rather than replace, generic good practice advice. In order to produce a practical document, in addition to raising awareness of key questions, contributors were asked to provide a context, identify potential barriers and give clear recommendations.

Potential barriers in MSOR

MSOR subjects are cumulative in nature so concepts may take time to be fully assimilated and this has an impact on teaching and assessment design. The Subject Benchmark Statement [4] notes that seeing extended arguments developed in 'real-time' is of benefit and this underlies the continuing dominance in some contexts of traditional board-based lectures. These may be supported by tutorials, problem classes and seminars which may also be board-based.

Many of the contributions to the guide highlight the need for full notes in specific formats to be provided prior to classes. For some, for example a student reading in Braille or large print, these notes may act as an alternative to the board. For others, the provision of notes alters the main activity from copying precisely, maintaining place in the text or retaining definitions in working memory to the desired engagement with concepts and logical arguments. Without this provision, the 'real-time' development of the argument cannot be followed. However, the very use of the board to facilitate this 'real-time' development may mean that no notes exist which can be converted for these students. This conundrum does not arise in the majority of subjects where extensive board use has all but disappeared.

This issue forms part of a wider challenge for the MSOR community, that documents and websites which contain mathematical content may themselves be a barrier. The Subject Benchmark Statement says that assessment should not be restricted to knowledge and understanding alone but also to the ability to communicate effectively in the context of MSOR. Reading and assimilating ideas typically expressed in two dimensional symbolic notation interspersed with text and diagrams is one specialist element of MSOR communication, along with developing effective written and oral communication of MSOR material with both peers and staff. However, no single format has yet emerged which can be read or transformed to be read effectively by all and this barrier is a recurring theme throughout the contributions to the guide.

Differing perspectives

A student may draw on support from needs assessors, assistive technology trainers, disability advisers, specialist mentors and study skills tutors, librarians, careers advisers, study support, examinations support and document conversion staff. E-learning specialists and computing services may be responsible for ensuring access to the virtual learning environment, computer systems and software. Most of these support professionals will not have substantial experience of mathematical subjects and, not unreasonably, may assume that generic approaches to access and inclusive design remain valid.

For example, it may be incorrectly assumed: that all electronic resources are accessible; that Braille, large or alternative print and speech formats can be produced automatically; that staff will typically provide documents in editable electronic formats; that standard optical character recognition and voice recognition software works; that students will know how to use software such as literacy support and mind mapping programs when faced with a proof or partial differentiation question; and, that standard study support tutorials will be effective.

Meanwhile, lecturers and tutors in mathematics, unlike their counterparts at a specialist school, are likely to have only limited knowledge in the domains of the support professionals listed above. Not unreasonably, they may assume that the student has been provided with assistive technology, training, human support and advice appropriate to the specialist nature of their studies and the ways in which MSOR content is communicated.

Understanding of the nature of mathematics, how it is communicated, taught and assessed, rests with the subject department. The contributions to the guide evidence the value of support professionals developing some understanding of the specialist nature of mathematics and of departments developing their technical and pedagogic offering in awareness of access challenges.

This leads to the recommendation that students, MSOR staff and support professionals should collaborate to identify MSOR specific barriers, find effective solutions and ultimately design inclusive curriculum delivery for the future.

Good practice guide

The good practice guide necessarily draws on the particular knowledge and interests of its contributors and cannot claim to provide a comprehensive picture. Nevertheless, with contributions from different stakeholders – academic staff, professional support staff, disability researchers and students – the guide aims to be a step towards the goal of working together to develop inclusive curricula.

The guide includes a collection of references to resources, sources of further information and key papers with short annotations. This list should enable departments seeking MSOR specialist information to discover resources more effectively.

Common threads that run through the contributions indicate common challenges for inclusive practice in MSOR. Contributions explore technical and pedagogic barriers and the way these may be formed by the modes in which mathematics is communicated. The contributions provide strong evidence of the need for collaboration between the MSOR community and the support professionals in dissolving these barriers and moving together towards the goal of inclusive curricula.

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Tony Croft and Duncan Lawson

sigma Network 2010/11 – More than the sum of the parts

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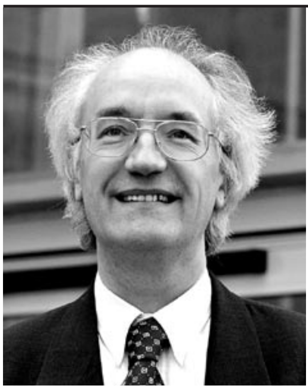

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Following on from the very successful **sigma** CETL programme, the **sigma** network project was officially launched in July 2010. Funded through the National HE STEM Programme and part of the Mathematical Sciences strand managed by the Institute of Mathematics and its Applications (IMA), the **sigma** network project focuses on disseminating good practice and information and stimulating the wider development of mathematics and statistics support provision based upon collaboration and the sharing of ideas.

The National HE STEM Programme recognised the success of support centres at Leeds, Bath and Sheffield Universities, initiated through **sigma** CETL pump-priming funding, as evidence of the effectiveness of this way of stimulating the development and adoption of student support. These three centres have been embedded into the Universities' respective Teaching and Learning strategies and are now fully funded internally. Following a competitive funding call, **sigma** provided similar pump-priming funding for five more support centres at the Universities of York, Lincoln, Kent, Central Lancashire and London Metropolitan University. As a result over 700 additional students have been supported in the past year.

Alongside the new centres, **sigma** CETL's successful regional hub pilot scheme has been developed into a wider Hub Network covering England and Wales. The original two hubs, South West and South Wales region led by Jane White (University of Bath) and the North East & Yorkshire hub jointly co-ordinated by Liz Meenan (University of Leeds) and Chetna Patel (University of Sheffield) have been joined by a further 4 hubs: the South East run by Martin Greenhow (Brunel University), the North West and North Wales hub co-ordinated by Sarra Powell (University of Liverpool), the Eastern England hub led by David Bowers (University Campus Suffolk) and the Midlands hub jointly co-ordinated by Duncan Lawson (Coventry University) and Tony Croft (Loughborough University). Each hub holds at least two events a year, develops and supports its constituency and contributes to the central **sigma** network.

sigma has worked with the Higher Education Academy's MSOR Network to maintain the annual CETL-MSOR conference – held this year at Coventry University and attended by over 100 delegates. We have also continued the **sigma** award scheme for outstanding contribution to the field of mathematics and statistics support as we believe it is vital to recognise the hard work and effort of colleagues in this important field.

As well as continuing previous good practice, the **sigma** network is keen to provide as much strategic support to the community as it can. To do this, we have begun work to develop an evaluation framework that can be used by the community; we have developed a training course for postgraduate students who provide mathematics and statistics support; we run resource development workshops which provide colleagues with dedicated time and space to develop resources for use by the whole community; and, we are piloting an innovative project to support part-time students in their workplace.

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Engineering Students Understanding Mathematics (ESUM)

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ESUM (Engineering Students Understanding Mathematics) is a developmental research project at a UK university. The motivating aim is that engineering students should develop a more conceptual understanding of mathematics through their participation in an innovation in teaching. A small research team (the authors) has both studied and contributed to innovation which included small group activity, a variety of forms of questioning, an assessed group project and use of the GeoGebra medium for exploring functions. The main study took place in the academic year 2010-11, but development is ongoing.[1]

Background to ESUM

A mathematics module for Materials Engineering students in a UK university has run for three years over two semesters with the same lecturers, a different one in each semester. In ESUM we focus on the first semester in which the lecturer has modified teaching each year, intending to create a more student-participative approach and encourage students to develop more conceptually-based understandings of mathematics. Modifications in previous years have had limited success [2] and the innovation in the third year was designed to be more coherent and far-reaching encompassing changes to how the module was delivered and the ways in which students interacted with the mathematics, the lecturer and each other. Innovation was undertaken by a research team of three teachers of mathematics (two with extensive experience of teaching engineering students and one, the lecturer, with extensive experience of mathematics teaching and teacher education at secondary level) who designed, conducted and reflected on teaching (the insiders), and a research officer (outsider) who collected and analysed data as agreed with the teaching colleagues.

The module was taught by one of the team (the lecturer) over 13 weeks with two lectures and one tutorial per week. The cohort of 48 students mostly had A-level mathematics with grades A to C, with just a few alternative qualifications; two students had no mathematics since GCSE. Lectures were timetabled in tiered lecture theatres. The weekly tutorial was held in a large computer laboratory with individual computer tables in squares of four, each set of tables accommodating one group of students. For the tutorials, students were grouped in threes and fours and expected to work together on set tasks and an assessed project. Tasks and project were designed for the module by the teaching team and formed a part of the innovation; both included inquiry-based questions designed to encourage exploration in mathematics using GeoGebra[2]. In addition, inquiry based questions were used in lectures along with more

[1] *This report is necessarily short. See Jaworski & Matthews, in press [1], for further details.*
[2] *GeoGebra:* ***http://www.geogebra.org/cms/***

traditional questions to encourage student involvement and provide feedback on understanding. Question design drew on a range of published resources.

Developmental Research in ESUM

The project had four phases: a design phase (of questions and tasks) preceded teaching and continued in parallel with the teaching phase of 13 weeks; a phase of data analysis followed involving the research officer and two members of the teaching team; a fourth phase (which is still ongoing) involves dissemination of findings and their use in the (re)design of the module for the subsequent year which is now underway.

Research was designed both to *promote* development and to *study* it [3]. Promotion was achieved by feeding back to teaching as data was collected and by creating an inquiry approach to teaching. The research studied the entire process through a rigorous analysis of data collected. The lecturer acted as a practitioner-researcher, reflecting on all activity and feeding back from observations and other data to ongoing teaching design and practice. The outsider researcher observed lectures and tutorials, with audio-recordings of lectures. She designed and administered two questionnaires for student data and feedback from teaching sessions and, with another member of the team, held one-one and focus group interviews with students at the end of the teaching semester. All research instruments and activity were agreed first with the teaching team.

Research Findings

Findings have come from both insider and outsider analyses. Insider analysis has involved reflective consideration of day to day activity, often with feedback to ongoing practice. Outsider analysis has involved a rigorous analysis of data collected from events. We summarise here the key findings of the project.

Compared with previous cohorts we have observed a much greater engagement in lectures. Inquiry-based questions have contributed to this, and the lecturer's deliberate use of a questioning approach has resulted in a much increased level of response from students (over previous cohorts). The lecturer in the second semester found remarkable responsiveness (over previous years), and the students' lecturer at the start of their second year has remarked similarly. Marks in tests and examinations were at a higher level (approximately 10%) than in previous years. Of course, this might have been a specially responsive and able group of students compared to previous years. We were not able to compare intake qualifications since the data from previous years was not available.

Students held mixed views about the values of the innovation to them. Analysis of focus group data revealed that:

1. While they could see that GeoGebra helped them to consider a wider range of functions and fit functions to data (as evidenced by their project reports), the need to draw by hand in an examination required more practice of graph sketching without GeoGebra. Dynamic use of GeoGebra in lectures was seen as sometimes interrupting lecture flow and taking unnecessary time.

2. Computer-based work in tutorials led to temptations to engage with social networking sites. Students would have preferred more opportunity to practice solving test or exam style questions.

3. Group activity worked well for some groups but was problematic when some students contributed little to the group. It was extremely valuable for some of the weaker students when their peers helped them to understand mathematical ideas. Some students felt that the group project could have been more demanding.

4. Students felt that too much time at the beginning of the module was spent on functions which they 'knew' already from A-level work. They would have preferred to spend more time on matrices and complex numbers which were relatively new for many of them.

It seemed clear that students came to the module with both traditional views on learning mathematics (e.g., wanting clear explanations and opportunity for practice) and a strategic approach to their studies (what is needed to pass the exam). We set out to create opportunity for more conceptual understanding of mathematics. We observed greater engagement and higher summative results than with previous cohorts. However, we were not able to measure conceptual understanding directly through our approach. An instrument to achieve this is being trialled with the new cohort.

Student perspectives are being fed into the new design: for example, starting the year with a focus on matrices and including practice-based work in tutorials alongside exploration with GeoGebra. The group project is being redesigned. The overwhelmingly positive outcome from ESUM is what we have learned as teachers about what engaged students and how they experienced the innovative approaches we have used. We are becoming more knowledgeable about the balance of activity, about specific elements of innovation and about the issues in developing conceptual understanding of mathematics. These feed into the overall module design; they also inform day to day practice in interacting with students and discerning their quality of understanding.

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Alexandra Shukie, Dave Kiddell, Nigel Thomson and Melissa Conlon

Supporting Undergraduate Engagement & Achievement in STEM Disciplines

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Background

This project aims to encourage engagement in STEM Higher Education through the development of an innovative, engaging & practical mathematics 'bridging' programme for new students enrolling on HNC, HND, FD and BEng programmes in Engineering.

The engineering courses are offered in full-time, part-time and intensive delivery forms. In intensive mode, a module is delivered over a continuous six day period. A large majority of applicants do not possess the level 3 mathematics qualification required to embark on the programme. The School offers such students the opportunity to take a level 3 bridging course in mathematics via the intensive route.

The School is not funded for the bridging course and therefore its only revenue comes from the minimal fee that the student pays of approximately £85. This course is offered five times during the academic year with, on average, ten students each time. In terms of staffing resources, the bridging course costs the School 250 hours.

Before this project began there were no online resources available to students on the Bridging Maths course. Those who had previously taken the module have expressed the desire to have the level 3 material to refer to for revision and refresher purposes whilst on their programmes.

This project will provide existing students with material/resources that can be used as revision purposes whilst progressing through their programme. Additionally, it is hoped that the intensive module could be delivered as a blended module, with students using the online material for self-study and attending College for two days rather than six.

Progress to date

The project team have conducted research into material and resources that are currently freely available online and although there was an abundance of material it was deemed not suitable for our purposes.

Utilising the already established Virtual Learning Environment (VLE) within Blackburn College, dedicated parent and child pages have been created on Moodle. The parent page will contain important information, such as information about the course, modules, a scheme of work and contact details for the disability and student support officers.

Under the parent page are child pages relating to topics that will be covered in the course containing information, videos, external links and quizzes related to the topic. To date four videos, three Camtasia videos and a number of online quizzes have been produced. There have been a number of issues related to adding mathematical symbols to Moodle, but these have now partially been solved by using a LaTeX equation editor.

The online materials will be trialled with a cohort of students in the autumn.

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Supporting progression in mathematics education

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Background

This project involved the creation of a final year project framework based on mathematics pedagogy. This would involve final year mathematics students[1] visiting a local secondary school to observe teaching to GCSE and A-level classes, preparing material in consultation with teachers and delivering this to classes of the appropriate level from the assisting school. This would benefit students interested in progressing from their degrees onto a PGCE course by providing them with insight and experience into the nature of mathematics education and assessment at secondary school level.

The project had the additional goals of addressing stereotypes about mathematics degrees and encouraging secondary school children into mathematics degree programs. The goal was to bring classes to Nottingham Trent University where the lessons could be delivered by the students. In addition, this visit was planned to include: a campus tour; question and answer sessions with staff and students; and, a talk on university life, the nature of mathematics courses and careers. Given the relative gender imbalance in mathematics degree intake it was decided that we would work with a girls' school.

Implementation

The project was made available to all final year students, regardless of gender, but it was made clear that those with an interest in female mathematics education would be prioritised. Two students (both female) applied to do the project and both were accepted.

The Nottingham Girls' High School agreed to participate in the project. This school has results well above the national average and it is usual for pupils there to attend university after their A-levels. While mathematics is a popular subject at A-Level it is usually seen as a useful entry requirement to some other field of study such as science or medicine and not taken as a degree subject itself. It was hoped that the campus visit would be useful in raising awareness of mathematics as a viable degree option.

The two participating students each researched an area of mathematics not currently part of the National Curriculum and developed lesson plans, supplementary materials and assessment tools suitable for GCSE and A-level. One student focused her project on cryptography and the other on fractals. Both topics were thought to be of appropriate mathematical complexity and interesting enough to motivate the school children. To satisfy the requirements of a final year project in mathematics each subject

[1] for clarity, 'students' is used to refer to the final year degree students and 'school children' or 'pupils' to the members of the GCSE and A-Level classes involved.

Schools and Colleges

was explored to a greater degree than was presented to the school children.

Two mathematics teachers at the Girls' High School took part, each acting as mentor to a particular student. The teachers were generous with their time and made themselves available by phone and email for consultation with the students. The students attended the teachers' maths classes on several occasions to observe and to assist where appropriate. During the first few months the students began to learn about teaching methods, learning styles, assessment methods and other pedagogic subjects.

In addition to writing their project scripts and producing an interim presentation, the two students built up lecture materials including hand-outs, group work sheets, feedback forms and lesson plans. A date was set for the visit and transport and catering was arranged. At this point the project experienced its first hurdle. One of the teachers who had been leading the project at the School end (the head of the mathematics department) was promoted to deputy head at short notice. Unable to spare the time that the project required she was quick to appoint a replacement to continue the project on her behalf.

Further pressure was applied to the project when one of the participating teachers arranged a holiday for the date of the visit. With less than a week to go we had to reschedule the visit. Given the tight timetable for project submission I felt that my first priority had to be ensuring that my students were not disadvantaged by a lack of time to write up the results of their projects. Instead of the school children visiting the campus our students went to visit them and delivered their classes at the school. Further problems were encountered when the rooms we had been told would be used were unavailable on the day. The alternative rooms lacked the expected facilities and this caused some last minute revisions (and concomitant nerves) for the students.

Evaluation

Whilst it was disappointing not to be able to provide the talks and tours that had been arranged, the actual lessons delivered by the students were well received by the teachers and the school children. Feedback suggested that the lessons had been considered to be of high quality by the teachers and interesting by the students. The group work on fractals was especially well received.

The projects themselves were marked, second marked and viewed by our external examiner. All agreed that they were of first class standard. The two students both graduated with first class honours and have been accepted onto PGCE courses. Both are firmly committed to a career in teaching and both show every sign of great promise in their careers.

Discussion, further development and sustainability

The project has been run again this year in a modified form with 4 students. I am working with a variety of schools so we will be less reliant on any single school. Each student is working with at least one unique school and all schools will be invited on the same day for visits.

One unexpected outcome of this project has been talks between our Mathematics and Education departments about a 'Mathematics Education' degree. It is hope that this will be ready (in a limited, pilot form) for 2012 entrants.

HE STEM
Project in brief:

Maths Busking

Using approaches developed by buskers to engage a crowd through street entertainment, this project seeks to engage the general public and school groups. Project leader: David Abrahams, Manchester. Supported by the Collaborative Practice Transfer Fund.

HE STEM
Project in brief:

Level 3 maths problem solving

To raise the standard of maths problem solving and so improve student transition to maths, science and engineering. Project leader: Sue Pester, WIMCS. Supported by the Wales Spoke.

HE STEM
Project in brief:

Sheffield Teacher Fellow

Introducing teacher fellows for projects to enhance the student experience of transition from school into University. Project leader: Alistair Warren, Sheffield. Supported by the North East Spoke.

Hazel Lewis

Mathematical Sciences Strand Outreach Work

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Work supported by the Mathematical Sciences Strand of the National HE STEM Programme.

The Institute of Mathematics and its Applications (IMA) outreach work for the National HE STEM Programme has broadly fallen into two themes. The first is sharing good practice between HEIs. We have helped HEIs discover good outreach work and supported them to run similar initiatives themselves. The vast majority of those we have supported say that they are keen to run activities in future years.

For example, at the University of Salford we supported Dr Edmund Chadwick to run his first Maths at Work Day, with employers delivering sessions for school pupils showing the utility of maths in the workplace. This format (described in [1]) has run successfully at other institutions for a number of years. Pupils are given a potentially life changing insight into jobs involving mathematics, while the organising HEI gets potential recruitment benefits and gains valuable links with employers and alumni.

We have also worked to share good practice from the Pilot Project More Maths Grads. A series of regional seminars for academics and outreach staff showcased the schools work, the collection of resources found in Maths in a Box [2] and the HE curriculum work of Sheffield Hallam University [3].

The second major theme has been developing new material to address particular issues which HEIs face in doing maths outreach. For example, departments find it difficult or time consuming to produce hands on activities for science fairs, careers fairs or open days. We sought ideas from people in HEIs who deliver such activities and produced: 1. a briefcase of small, hands on activities; 2. seven large apparatus which can be borrowed free of charge from the IMA (you pay the shipping costs).

These are just a few examples of our work. If you want to know more, then please email Hazel Lewis on hazel.lewis@ima.org.uk.

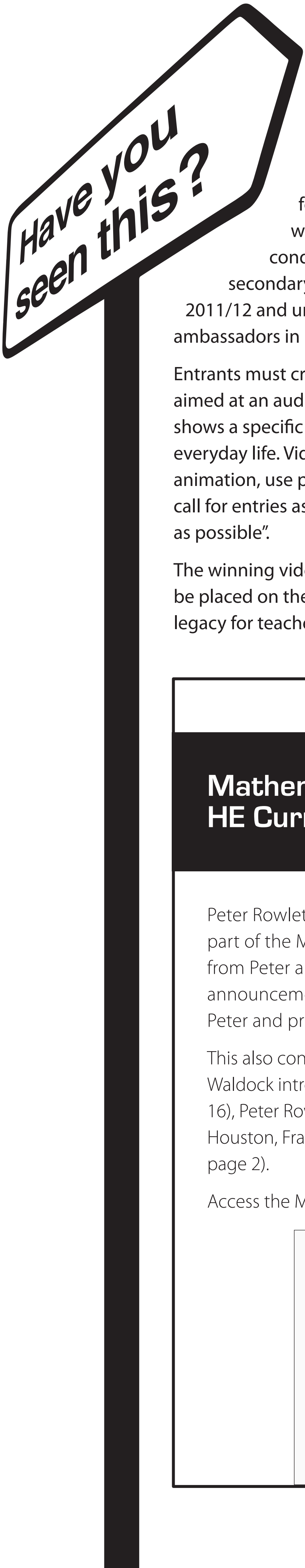
For pictures of some items from the Maths Outreach Kits, see page 56.

References

1. More Maths Grads, 2009. *Outreach to Schools: A Good Practice Guide*. Via: http://www.nationalstemcentre.org.uk/elibrary/resource/2070/outreach-to-schools-a-good-practice-guide [Accessed 26/09/11].

2. Maths Careers, 2011. *Maths in a Box download page*. Via: http://www.mathscareers.org.uk/viewitem.cfm?cit_id=382988 [Accessed 26/09/11].

3. Robinson, M., Challis, N. and Thomlinson, M., 2010. *Maths at University: reflections on experience, practice and provision*. More Maths Grads. (Downloadable via [2]).



Maths ambassador video competition

Peter Rowlett, MSOR Network

The Maths Careers website (**www.mathscareers.org.uk**) has launched a competition for undergraduate students who are student ambassadors conducting outreach support in secondary schools and colleges during 2011/12 and undergraduates who were ambassadors in 2010/11.

Entrants must create a 2 minute video which is aimed at an audience of 11 to 16 year olds and shows a specific application of GCSE maths in everyday life. Videos can feature people, be an animation, use puppets or anything else – the call for entries asks entrants to "be as creative as possible".

The winning video and the ten runner-ups will be placed on the Maths Careers website as a legacy for teachers to use in the classroom.

First prize is a laptop and there are ten runner-up prizes of £20 Amazon vouchers.

This sounds like an interesting project for students to get involved with and a great prize. I encourage you to pass these details to any relevant students.

The closing date for entries is 30th June 2012. A set of rules and instructions on submitting entries is available on the Maths Careers Website [1].

This competition is supported by the Institute of Mathematics and its Applications as part of the Mathematical Sciences Strand of the National HE STEM Programme.

References

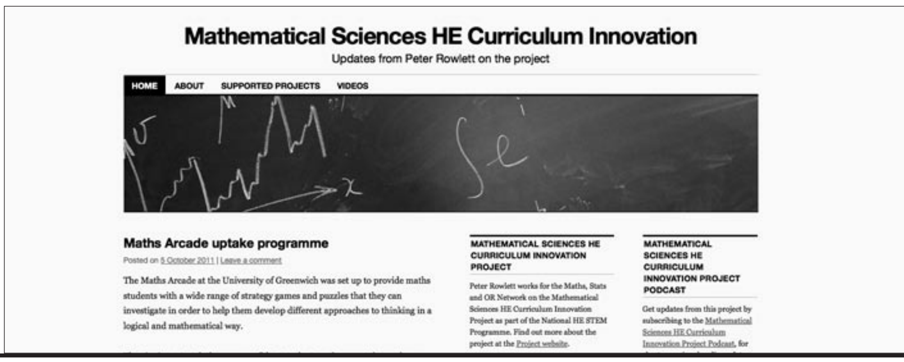
1. Maths Careers, 2011. Get into the Big Screen! http://www.mathscareers.org.uk/viewItem.cfm?cit_id=383238 [Last accessed 09/10/11].

Mathematical Sciences HE Curriculum Innovation Project blog

Peter Rowlett works for the Maths, Stats and OR Network on the HE Curriculum Innovation Project as part of the Mathematical Sciences Strand of the National HE STEM Programme. You can get updates from Peter about the HE curriculum innovation work via the project blog. These include project announcements, upcoming workshops, progress on supported projects and short audio updates from Peter and project leaders.

This also contains a list of recordings of sessions given as part of this project, including videos of Jeff Waldock introducing the 'Developing Graduate Skills in HE Mathematics Programmes' booklet (see page 16), Peter Rowlett at the Young Researchers in Mathematics 2011 Conference (see page 20) and Kevin Houston, Franco Vivaldi and Mike Robinson at the 'Teaching students to write mathematics' workshop (see page 2).

Access the Mathematical Sciences HE Curriculum Innovation Project blog via: **mathshe.wordpress.com**



Tony Mann

Workshop report: 'Ideas Exchange: HE Mathematics Curriculum Innovation'

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Workshop supported by the HE Curriculum Innovation project, part of the Mathematical Sciences Strand of the National HE STEM Programme.

At the end of another long academic year, when one might expect academics to be thinking only of summer vacation, research and perhaps even holidays, a group of mathematicians assembled in Birmingham to spend a weekend discussing ideas for innovation in mathematics teaching. The brief was to exchange new ideas for teaching mathematics in higher education, with a view to identifying projects which might be pursued collaboratively and proposals which might be submitted to the National HE STEM Programme Mathematics Curriculum Innovation Fund for possible support.

The mix was interesting, in that there was representation from different kinds of institution and delegates were varied in terms of experience and area of expertise. Universities represented were Aston, Greenwich, Keele, Manchester Metropolitan, Nottingham, Salford, and Sheffield Hallam. The format of each session required three of us to make five-minute pitches, after which we were then sent to a break out room where other delegates could come to discuss our ideas. This worked well in stimulating discussion, which tended to range widely, and the coffee and meal breaks provided further opportunities for animated conversations.

In accordance with our brief, the ideas put forward for discussion ranged from innovations we had successfully used with students, through plausible extensions of existing practice or projects people had not yet had the opportunity to develop, to wild and unlikely speculation which might be refined by feedback from like-minded colleagues into something workable.

I opened with a pitch about using jokes to communicate mathematical thinking. My presentation of the old proof that Alexander the Great had infinitely many arms perhaps failed to persuade the audience, but discussion afterwards focused on the idea that suitable mathematical jokes (or magic tricks and illusions, the subject of my subsequent pitch) can be an effective way to dispel students' misconceptions. As a result we concluded that a joint project to assemble a library of jokes and demonstrations to address common student misunderstandings might be worthwhile.

David Bedford and Mike Peters made a presentation demonstrating the value of video conferencing as a means of conducting tutorials. We learned from Neil Challis how computer software could support problem-based learning in geometry – a long way from Euclid! Those of us not already using GeoGebra realised that this is something we need to investigate.

Killian O'Brien demonstrated the use of tablet computers to create short video clips of worked mathematical examples – a particularly easy way to capture mathematical thinking, and a reminder of how technology can enhance mathematics teaching and learning in ways that are not immediately obvious.

The vexed question of groupwork, and how to allocate students to groups without tears, was addressed by Noel-Ann Bradshaw: this led to discussion on Twitter with contributions from some who were unable to attend the event. Noel-Ann also talked about the 'Maths Arcade' she set up at Greenwich and is developing with HE STEM funding (see page 26). This has helped student engagement and seems to have improved retention: as a result of this weekend, the National HE STEM programme has agreed to help other universities implement this initiative.

The Saturday finished with 'entertainment' – demonstrations of tricks and puzzles that are useful as refreshers to break up a long class or as cliff-hangers to keep students engaged over a short break. Peter Rowlett talked about the 14-15 puzzles, Killian O'Brien demonstrated a topological rope trick, David Bedford posed a counter-intuitive problem about an ant on an elastic band, and I did some mind-reading.

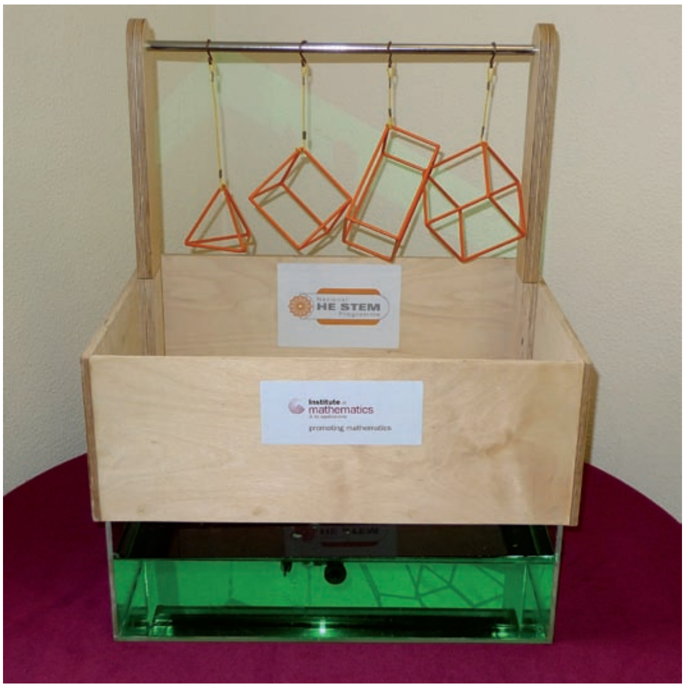
The Sunday morning began with a special guest, claiming to be Gottfried Leibniz but bearing some resemblance to Noel-Ann Bradshaw, arguing that the occasional use of period costume might be effective in engaging students and creating memorable learning experiences – this is effective in outreach activities, so why not in regular teaching? Could 'applied drama' enhance student learning? There was discussion as to whether departments might be able to share the potentially expensive costumes.

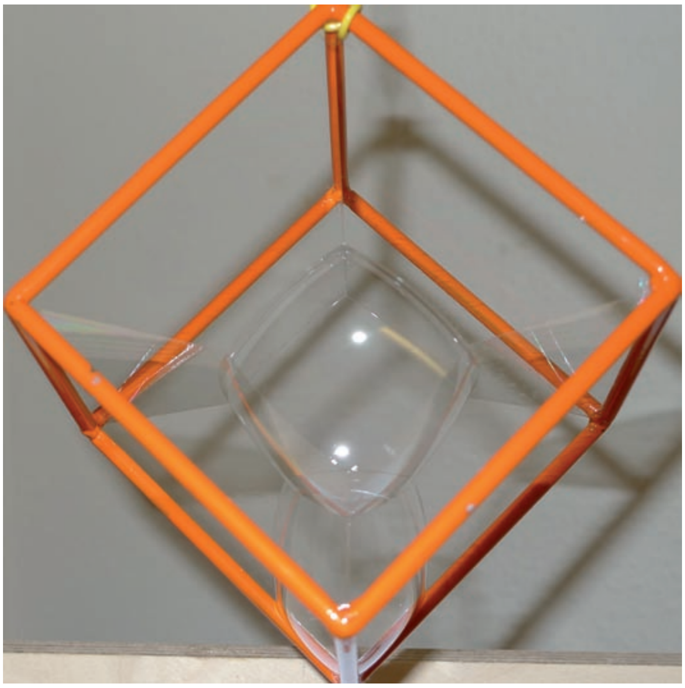
Killian O'Brien asked us to think about how to deal with student 'howlers' in exams – do we discount them as purely the outcome of stress or do we read them as signs of deep lack of understanding and try to address them? This connected with Peter Rowlett's reflections on how we present mathematics to students – too often we only show the finished product and not the false starts and mistakes that are inevitable when mathematics is created.

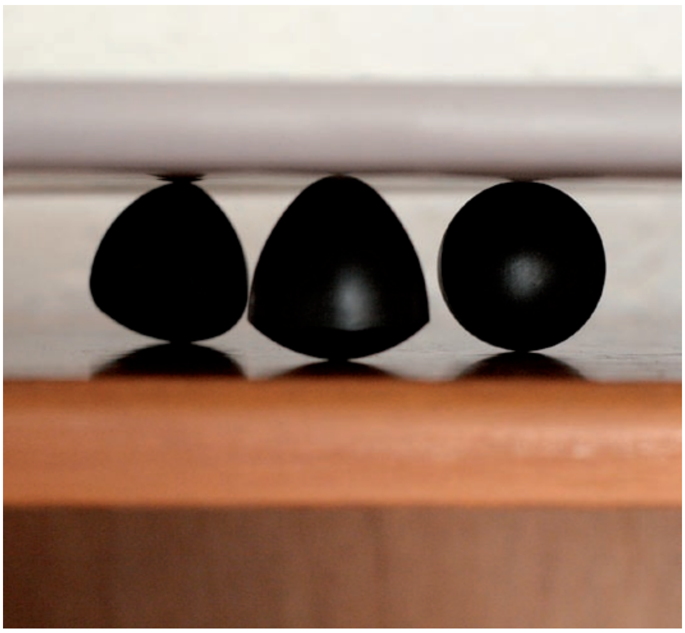
In the final session Sally Barton talked about the use of puzzles in transition and mathematics support – once again all about promoting engagement, and Edmund Chadwick complemented this in telling us about his use of puzzles like Rubik's Cube to convey mathematical ideas.

This was a fascinating and productive weekend. It is always worthwhile to talk to colleagues about teaching maths, and this differed from other valuable events such as the CETL-MSOR Conference in that we were encouraged to put forward half-formed (and indeed perhaps half-baked) ideas that might just work. The discussion helped share, clarify and develop these ideas. The emergence of common themes, such as the use of games and puzzles in different learning contexts – was thought-provoking and encouraging. The best thing about the weekend was that new collaborations were emerging, and ideas were going to be taken back to be discussed with colleagues at our own institutions. These are exciting times for mathematics in HE.

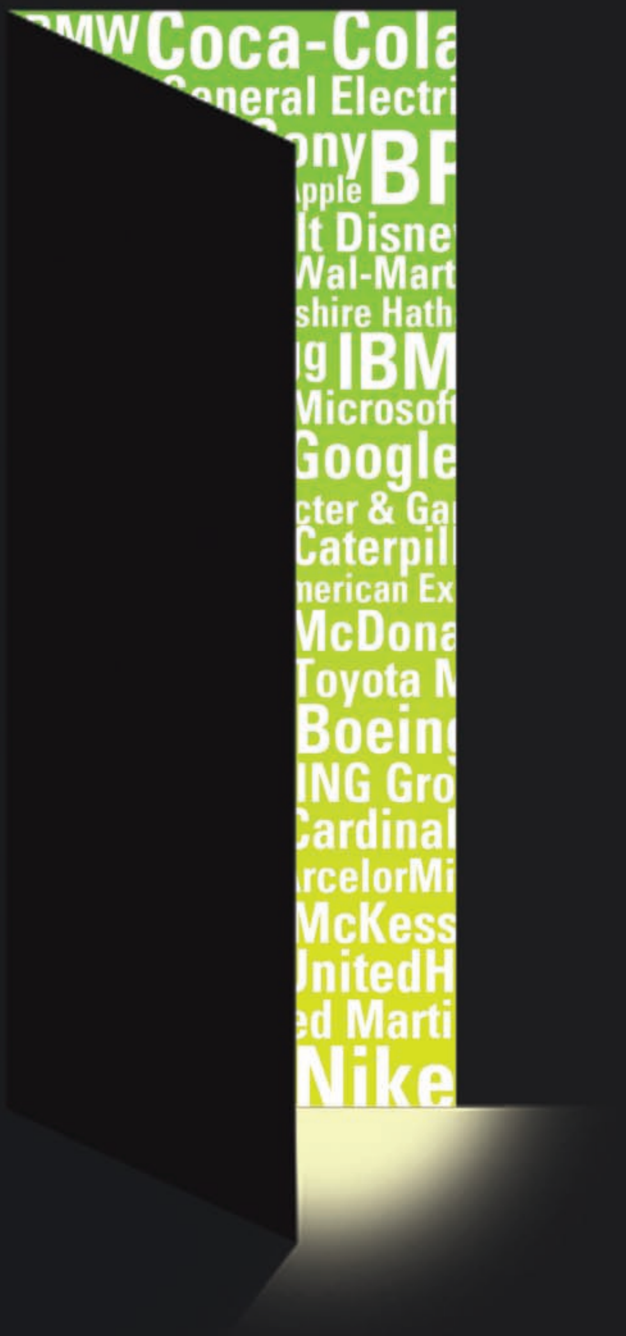
Fig 1 – Gottfried Leibniz attended the Ideas Exchange to talk about the use of drama to enhance student learning.

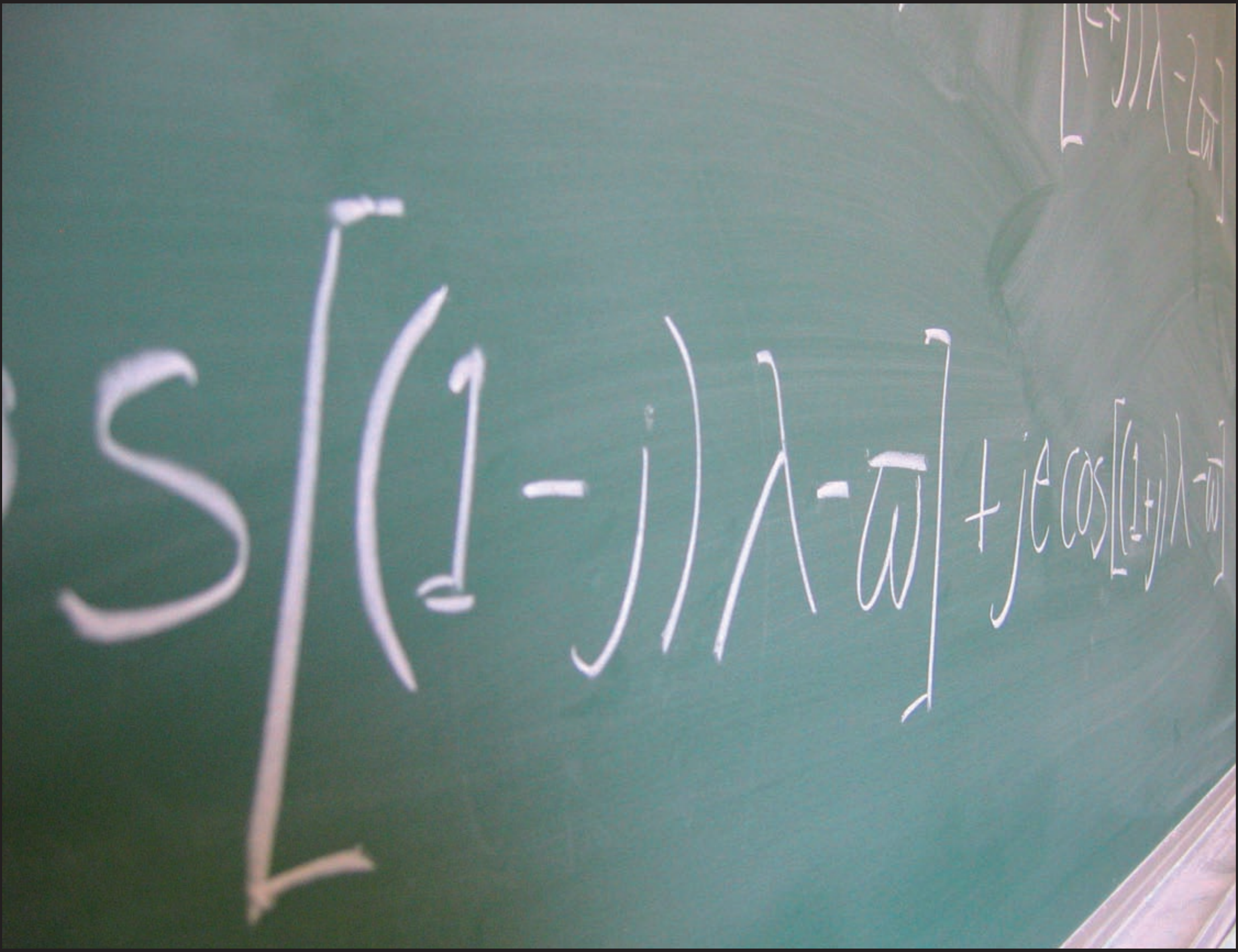






Some items from the Maths Outreach Kits (see page 52). Clockwise from top left:
Soap Bubble Experiments.
Soap Bubbles form surfaces with the least area.
Galton Board.
Solids of constant width.
Trebuchet.


Google
IBM
Nike



Mathematical Sciences Strand of the National HE STEM Programme

The National HE STEM Programme is funded by the Higher Education Funding Councils for England and Wales and seeks to support Higher Education Institutions in encouraging the exploration of new approaches to recruiting students and delivering programmes of study. It enables the transfer of good practice across the HE STEM sector, facilitates its wider adoption, and encourages innovation. Through collaboration and shared working, the Programme focuses upon sustainable activities to achieve long-term impact within the HE sector.

The Mathematical Sciences Strand of the National HE STEM Programme is operated by the Institute of Mathematics and its Applications on behalf of a group of societies and others in the mathematical sciences which also includes the Royal Statistical Society, the London Mathematical Society and the Heads of Departments of Mathematical Sciences (HoDoMS).

The IMA is assisted on HE curriculum innovation by the MSOR Network. The HE curriculum innovation activities explore current learning, teaching and assessment practices within mathematical sciences departments, and disseminate good practice. This component fits into a wider programme of activity in mathematical sciences, where the IMA is working on integration and diversity, employer engagement and, with **sigma**, on mathematical sciences support.

Find out more about the Mathematical Sciences HE Curriculum Innovation Project and links to the other partners via: **www.mathstore.ac.uk/hestem**

National HE STEM Programme

Institute of mathematics & its applications

The Higher Education Academy Maths, Stats & OR Network

centre for excellence sigma in mathematics & statistics support