Mathematical Sciences HE Curriculum Innovation Project

Summary of work in mathematical sciences HE curriculum innovation

Edited by Peter Rowlett

The Higher Education Academy Maths, Stats & OR Network

National HE STEM Programme

Institute of mathematics & its applications

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July 2012

Summaries of work coordinated by the Maths, Stats and OR Network, working with the Institute of Mathematics and its Applications as part of the National HE STEM Programme.

www.mathstore.ac.uk/hestem

Download resources listed in this booklet by visiting www.mathcentre.ac.uk/staff/topics and looking under 'HE STEM Projects'.

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National HE STEM Programme

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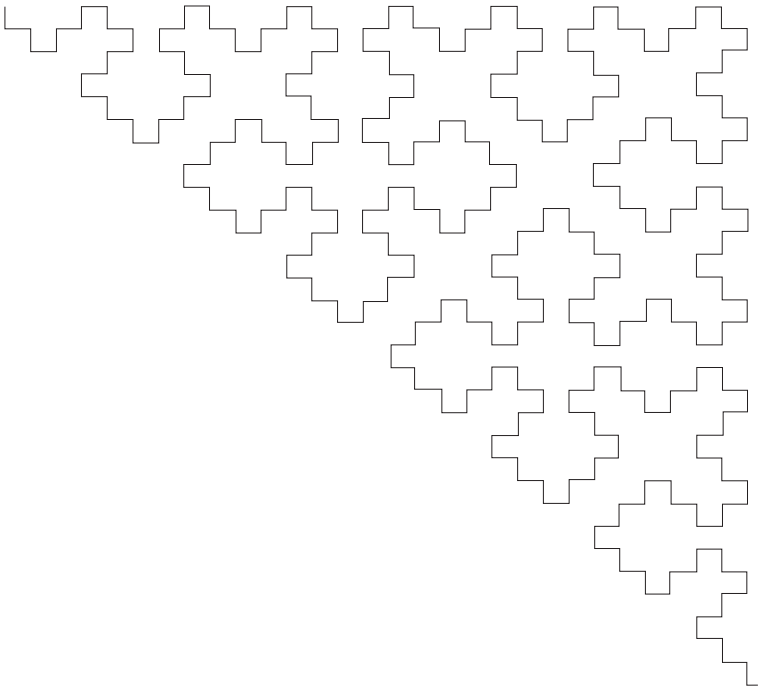
Contents

Download a copy of this booklet via www.mathcentre.ac.uk/resources/uploaded/HESTEMOverview.pdf

Projects in this booklet are listed with approximate funding amounts to indicate the scale of each activity. These comprise the funding issued to each project and additional direct costs such as printing a report or catering and room hire for a workshop, where these were provided by the MSOR Network. No costs are allocated to individual projects where project reports are published in a collection, where projects contribute a session in a wider event or for electronic publishing. Design costs and MSOR staff time (including, for example, for publishing reports or running workshops) are not attributed to projects. Amounts are rounded appropriately to their scale.



Introduction

This booklet provides an index to a set of work on mathematical sciences HE curriculum development.

In the academic years 2010/11 and 2011/12 the Maths, Stats and OR (MSOR) Network supported a set of 32 projects through funding of around £250,000. This work was completed with the Institute of Mathematics and its Applications as part of the Mathematical Sciences Strand of the National HE STEM Programme. The National HE STEM Programme was an initiative aiming to enable the HE sector to engage with schools, enhance curricula, support graduates and develop the workforce, operating through a three-year grant from the Higher Education Funding Councils for England and Wales (HEFCE & HEFCW). This work on Mathematical Sciences HE Curriculum Innovation had the aim to produce:

> *"Higher Education curriculum developments focusing upon course delivery and design and student support, to enhance student knowledge, progression and skills."*

These projects have lots to share – good practice advice, evaluated innovative approaches, problem banks and other curriculum resources that you can pick up and use right away, and much more. This booklet provides details of the aims, objectives, outputs and outcomes of each project. Links are provided to access the resources created by each project. Projects are arranged into themed sections.

Developing graduate skills: A booklet was published collecting case studies of successful methods to improve graduate skills development – skills that employers require from graduate employees and academics seek in incoming PhD students – within a mathematical context. Three mini-projects were commissioned based on these case studies and provided evidence that some of this practice is suitable for transfer elsewhere. In addition, mathematics-specific resources and teaching practice on speaking and writing skills were developed and shared.

Engaging with employers: Projects working with employers, employees or professional bodies, either in delivery of a curriculum approach or providing input to develop good practice advice or curriculum resources that you can use. This includes resources giving an idea of what it is like to work as a mathematician and a survey of graduates' views of the mathematics HE curriculum.

Industrial problems: Banks of real world problems developed in consultation with industrial partners made available for undergraduate projects in mathematics and statistics.

Problem-solving: Two projects working to share good practice and develop curriculum resources on the teaching of problem-solving. We say mathematics develops problem-solving but do we actually know how to develop problem-solving as a skill in our students?

Maths Arcade: An innovative practice involving developing mathematical thinking, providing student support (particularly at the transition to university) and building a staff and student mathematical community. A case study booklet gives details of its implementation at eight universities.

Student-centred Approaches: Projects working to accommodate student needs or taking a student-centred view on improving the undergraduate experience. Including methods for supporting students in different contexts, helping engineers better understand their mathematics and providing adjustments for students with disabilities.

Assessment: A major project conducted research to answer questions about what alternative methods of assessment can offer, evidence of validity and guidance on the process of changing your teaching to involve a new assessment type.

Audio-visual media in teaching and learning: Investigating the recording of lectures and other teaching and learning content, and the effectiveness of learning through audio-visual media.

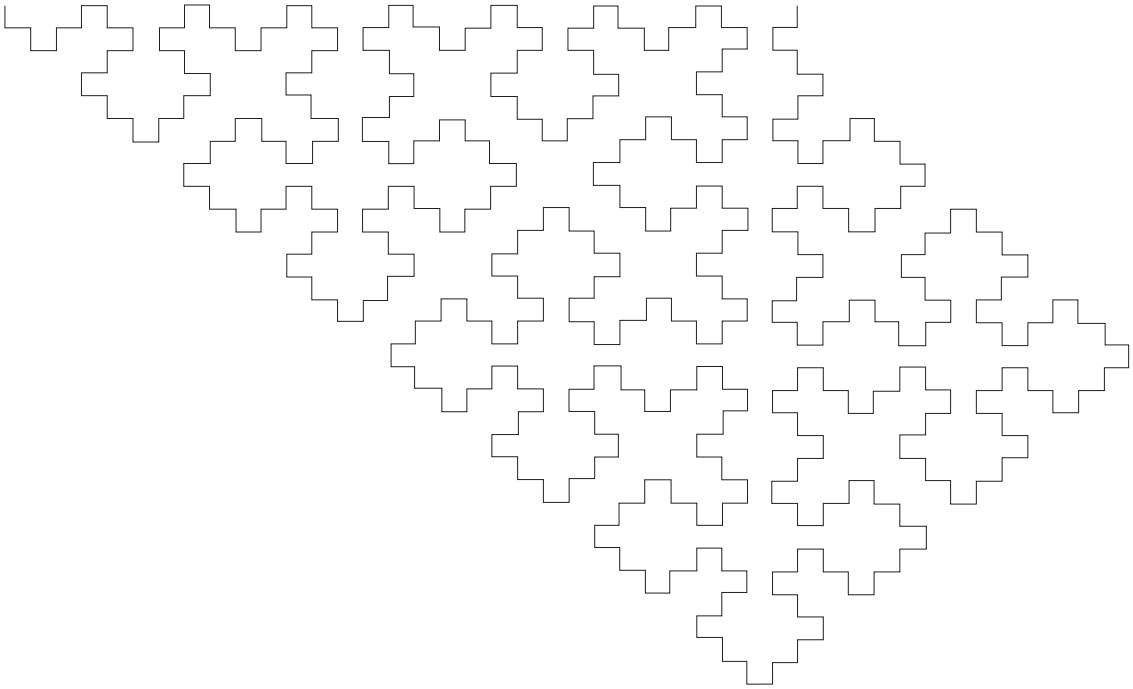
This funding was distributed via a series of funding calls (see appendix A for a timetable). Around 70% of the funding was allocated to addressing the recommendations of the HE Mathematics Curriculum Summit (see page 9 for a description and page 11 for a list of projects addressing the recommendations). In order to allow for interesting innovation which could not be predicted, calls for funding always included an open call for projects fitting the National HE STEM Programme aims. Around 30% of the funding allocated was for new innovations discovered this way.

All funding was provided to HEFCE- or HEFCW-funded institutions. Counting everybody who was named as a project collaborator or as an author in one of the publications (but not those who, for example, spoke at one of the workshops), this booklet represents the work of more than 120 individuals working at 41 UK higher education institutions, two professional bodies, two schools, three non-UK universities and various companies (see appendix B for a list of people in UK higher education grouped by institution).

There were over 50 workshops, seminars and conference presentations associated with this work (see appendix C for a list). 15 major publications arose from this work and the work was reported via articles in the professional body and learned society newsletters and others throughout the process (see appendix D for a list).

Projects have completed research and collected good practice advice, developed innovative practice or produced and shared curriculum resources to address various issues in mathematical sciences HE curriculum development. The work includes the need to develop graduate skills and take account of employer requirements, while remembering to ground this in mathematical content and take account of the needs of the discipline. How the collected resources affect the ability of the higher education mathematical sciences community to more effectively develop graduate mathematicians depends on how well these are taken up. This substantial set of projects in curriculum development has produced outputs with the potential to be very useful. Please use them!

Peter Rowlett
Maths, Stats and OR Network
June 2012



HE Mathematics Curriculum Summit

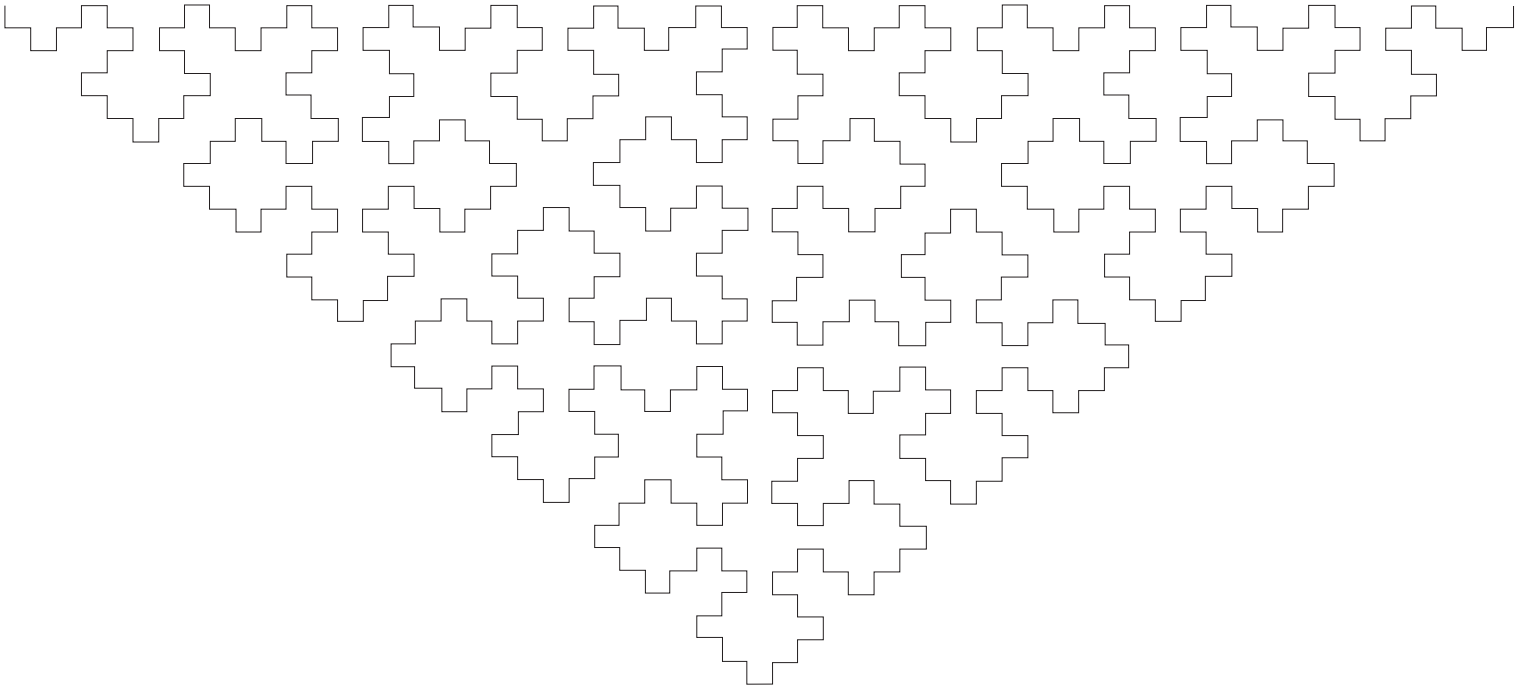
The HE Mathematics Curriculum Summit took place under this project at the University of Birmingham on 12 January 2011. This brought together: Heads of Mathematics or their representatives from 26 universities offering mathematics degrees (about half of those in England and Wales); Education representatives 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 (MSOR Network Director) and opened with a debate, in which Prof. Alexandre Borovik (University of Manchester) proposed and Jon McLoone (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 (IMA). The Summit heard and discussed presentations from Prof. Jeremy Levesley (University of Leicester) on 'Taking control of the assessment agenda' and Dr. Neil Challis (Sheffield Hallam University) 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 [1]. About 70% (by funding) of the work supported by this project and listed in this booklet aims to address the curriculum development priorities recommended by the final Summit discussion sessions. The table on page 11 indicates which Summit recommendations were addressed, and where this work is reported in this booklet.

References

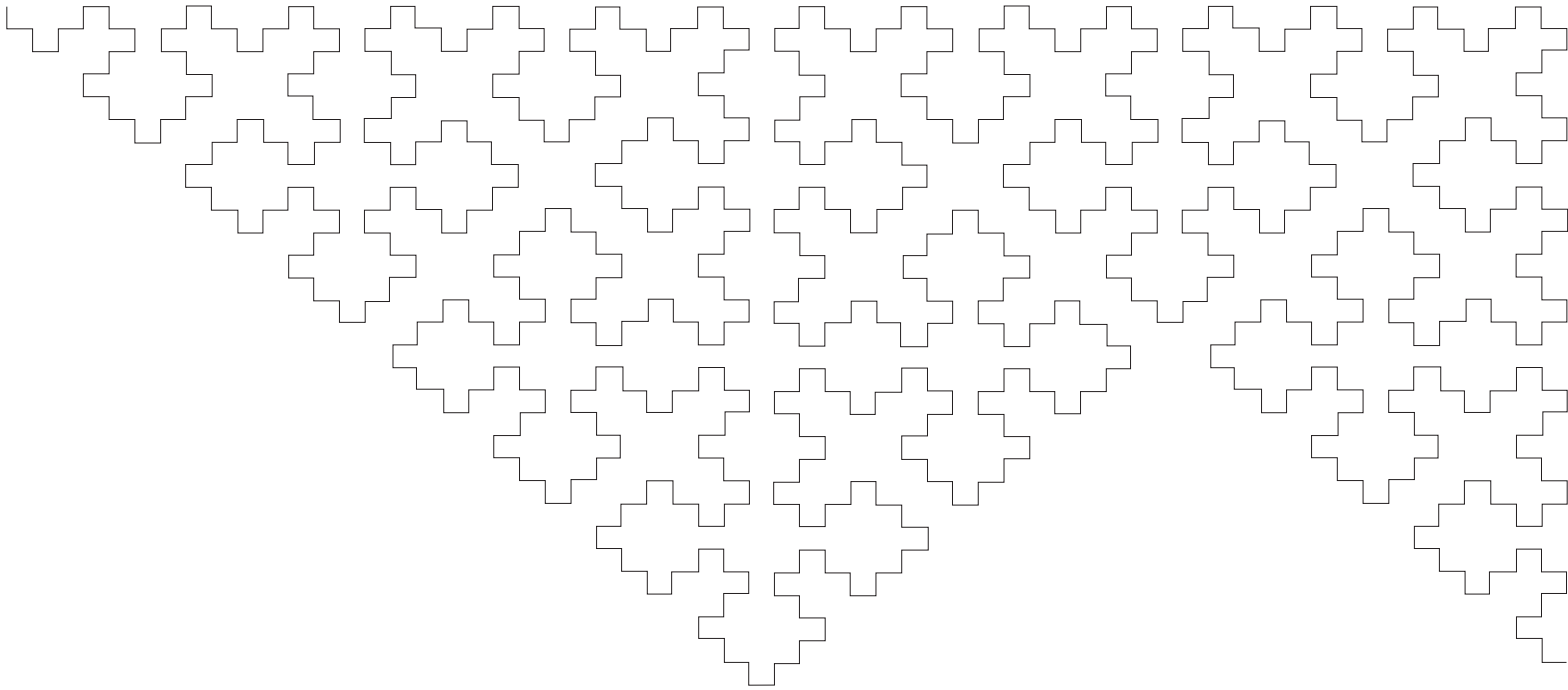
1. Rowlett, P. (ed.), 2011. *HE Mathematics Curriculum Summit*. Birmingham: MSOR Network. Available via: www.mathcentre.ac.uk/resources/uploaded/SummitReport.pdf



Summit recommendations taken forward

The full text of these recommendations is given in the Summit report (see page 9). This list is intended to indicate which recommendations were addressed and by which projects.

Problem-solving	1. Sharing good practice; 2. Development of a bank of problems.	Two projects on Problem-solving (pp. 35-37).
	3. Development of a collection of teaching resources on the process of doing and development of mathematics.	Being a Professional Mathematician (p. 24).
Industry	4. Development of a bank of industry-based problems.	Industrial Problem Solving for Higher Education Mathematics (p. 32); Industrial Problems for the HE Curriculum in Statistics (p. 33).
	5. Extending the model of the 'study groups with industry' to undergraduate project work.	Not taken forward directly; encouraged through reports in *MSOR Connections*, 11(3), pp. 8-10.
	6. Undergraduate student industrial placements.	Models of industrial placements (p. 27).
Assessment	7. Research project on innovative approaches; 8. Sharing good practice.	MU-MAP – Mapping University Mathematics Assessment Practices (p. 54).
Skills	9. Resource development: maths-focused resources on communication skills.	Enhancing the communication and speaking skills of mathematics undergraduates (p. 18); Teaching Students to Write Mathematics (p. 19).
	10. Building on the Developing Graduate Skills case studies (see p. 14).	Mathematical Presentation and Communication Skills within the Core Curriculum (p. 15); Maths Careers: Greenwich Graduates where are they now? (p. 16); Progress Files – Greenwich Implementation (p. 17).
Sustainability	11. Education for Sustainable Development.	Not taken forward directly; see HE STEM project 'Green STEM' at www.hestem.ac.uk.
Miscellaneous	12. Sharing good practice through an inter-university teacher exchange programme.	Taken forward through a travel grants scheme available from March 2011–July 2012.
	13. Undergraduate summer intern projects within universities.	Not taken forward directly as a pilot scheme was already in development by **sigma**; see *MSOR Connections* 11(3), pp. 13-14.
	14. Research to collect feedback of graduates in employment on the mathematics HE curriculum.	Views of graduates on the HE curriculum (p. 23).



Developing graduate skills

Skill development is clearly important but takes time and this raises a concern that improving students' graduate skills (the skills that employers are looking for in graduates and academics are looking for in PhD students) will take time away from developing the mathematical curriculum. In addition, students are thought to be unlikely to engage well with fairly generic lessons on skills development.

Jeff Waldock recognises the difficulty of "finding space for graduate skill development in a crowded curriculum" and considers this might be addressed by taking "different approaches toward learning, teaching and assessment that allow skill development to take place alongside the development of the mathematical skills", by "encouraging students to take part in extra-curricular activities" and by improving students' awareness and articulation of their skills development. Seventeen short case studies provide examples of developing graduate skills within a mathematical context at a diverse set of fifteen universities.

Three further mini-projects look to draw inspiration from the original case studies and transfer their ideas to new institutions. Following successful transfer, all three will be embedded in their institutions in future years and this provides evidence that this practice can be successfully transferred to new settings.

Meanwhile, the HE Mathematics Curriculum Summit made a recommendation concerning the production of maths-focused communications resources equivalent to already published generic resources which may not fully take account of issues in communicating mathematical content. Two projects focused on speaking and writing skills in mathematics, producing advice and teaching resources to assist others in improving their provision.

The following section 'Engaging with employers' (page 21) lists projects addressing graduate skills development from the point of view of involving employers and employer feedback in the curriculum.

Key Resources

Waldock, J. (ed.), 2011. *Developing Graduate Skills in HE Mathematics Programmes – Case Studies of Successful Practice*. MSOR Network.
Available via: www.mathcentre.ac.uk/resources/uploaded/GradSkills.pdf

Rowlett, P. (ed.), 2012. *Further Work Developing Graduate Skills in HE Mathematics Programmes*. MSOR Network.
Available via: www.mathcentre.ac.uk/resources/uploaded/FurtherGradSkills.pdf

Houston, K. (ed.), 2011. *Teaching Students to Write Mathematics* (DVD).
Available via: www.kevinhouston.net/dvds/writing-math.html

Developing Graduate Skills in HE Mathematics Programmes

This project collected and shared good practice in curriculum interventions to develop graduate skills in HE mathematics programmes through a booklet and a series of workshops. These provided ideas to stimulate change elsewhere.

Project Leader: **Jeff Waldock**

Institution: **Sheffield Hallam University**

Funding: **HE Curriculum Innovation / £6,500**

Collaborators

Contributors: Louise Walker, University of Manchester; Mary McAlinden, Oxford Brookes University; Sidney Tyrrell, Coventry University; Stephen Hibberd, University of Nottingham; Peter Rowlett, Nottingham Trent University; Kevin Golden and Guy Roberts, University of West of England; Kevin Houston, University of Leeds; Edmund Chadwick, University of Salford; Peter Samuels, Birmingham City University; Gareth Williams, Open University; David Bowers, University Campus Suffolk; Vicki Tariq, University of Central Lancashire; Valerie Matthews-Lane, Clive Rix and Richard Mendez, University of Leicester; David Graham and Annette Millar, Plymouth University.

Aims

To investigate and share good practice on curriculum interventions aiming to develop graduate skills in HE mathematics programmes.

Objectives

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 (for which encouragement and recognition is now offered by many universities through award schemes) this project investigated curriculum-based approaches. This included specific additional activities - such as placements, where offered - but also took account of developments in the approaches taken to learning, teaching and assessment.

To share the published resources through a national workshop tour of five workshops.

Outputs

A booklet of seventeen case studies for fifteen universities was published.

A video recording of the workshop introduction is available online.

Outcomes

The case study information and guidance will help staff at all institutions in adapting their own programmes to incorporate the development of graduate skills. This project provided ideas to stimulate change elsewhere.

Resources

Waldock, J. (ed.), 2011. *Developing Graduate Skills in HE Mathematics Programmes – Case Studies of Successful Practice*. MSOR Network.

Video of the introductory workshop session by Jeff Waldock.

Both available via: www.mathcentre.ac.uk/topics/hestem-projects/grad-skills

Mathematical Presentation and Communication Skills within the Core Curriculum

This project established the case for transfer of good practice originally captured through the *Developing Graduate Skills* booklet, drawing on experience from Leeds, Birmingham City and Coventry to raise the importance for students of developing their graduate skills.

Project Leader: **Andrew Neate**

Institution: **Swansea University**

Funding: **Developing Graduate Skills Uptake Programme / £1,000**

Collaborators

Kristian Evans, Swansea University.

Aims

The HE Mathematics Curriculum Summit made a recommendation: "Building on the case studies collected by the mini-project 'Developing Graduate Skills in HE Mathematics Programmes'". This mini-project aimed to spread and build on the good practice identified in that collection of case studies.

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 so fail to engage in developing such transferable skills. This project aimed to raise the importance that students place on these aspects of their education from the very beginning of their time at university.

Objectives

To run a series of workshops covering transferable skills as part of the normal lecture programme and reinforce these through feedback on assignments and general tutorial support.

Outputs

Case study report.

Outcomes

Feedback from students and staff having been extremely positive, this activity will be repeated in future years at Swansea.

Good practice identified in the *Developing Graduate Skills* booklet has been spread to another institution. Further, the case for spreading this good practice beyond one institution has been made.

Resources

Neate, A. and Evans, K., 2012. Mathematical Presentation and Communication Skills within the Core Curriculum. *In*: P. Rowlett (ed.), *Further Work Developing Graduate Skills in HE Mathematics Programmes*, pp. 12-13. MSOR Network.

Available via: www.mathcentre.ac.uk/resources/uploaded/FurtherGradSkills.pdf

Maths Graduates: where are they now?

This project established the case for transfer of good practice originally captured through the *Developing Graduate Skills* booklet, drawing on experience from Manchester to engage recent graduates with current students to draw links between graduate skills and employment needs.

Project Leader: **Noel-Ann Bradshaw**

Institution: **University of Greenwich**

Funding: **Developing Graduate Skills Uptake Programme / £1,000**

Aims

The HE Mathematics Curriculum Summit made a recommendation: "Building on the case studies collected by the mini-project 'Developing Graduate Skills in HE Mathematics Programmes'". This mini-project aimed to spread and build on the good practice identified in that collection of case studies.

The University of Greenwich's Maths Careers afternoon aimed to enable current maths students to hear first-hand from recent graduates how and when to apply for jobs and what different careers entail.

Objectives

To invite representatives from several industries including banking, insurance, teaching, transport, analytics and mathematical modelling to give presentations and answer questions on their careers; mostly early career mathematicians who will be able to understand the needs of our students.

To prepare an Employability Skills Guide showing students how to develop their skills and explaining the link between final year options and career choices.

Outputs

Case study report.

Outcomes

This activity was so successful and received such positive feedback that it will be repeated in future years at Greenwich. An employer mentoring scheme has been recommended as a result of this project and this will be investigated.

Good practice identified in the *Developing Graduate Skills* booklet has been spread to another institution. Further, the case for spreading this good practice beyond one institution has been made.

Resources

Bradshaw, N., 2012. Maths Graduates: where are they now? *In*: P. Rowlett (ed.), *Further Work Developing Graduate Skills in HE Mathematics Programmes*, pp. 10-11. MSOR Network.

Available via: www.mathcentre.ac.uk/resources/uploaded/FurtherGradSkills.pdf

Progress Files – Greenwich Implementation

This project established the case for transfer of good practice originally captured through the *Developing Graduate Skills* booklet. This project learned from the experience at Sheffield Hallam University to enhance the Greenwich provision on self-reflection.

Project Leader: **Tony Mann**

Institution: **University of Greenwich**

Funding: **Developing Graduate Skills Uptake Programme / £1,000**

Collaborators

Steve Lakin, University of Greenwich.

Aims

The HE Mathematics Curriculum Summit made a recommendation: "Building on the case studies collected by the mini-project 'Developing Graduate Skills in HE Mathematics Programmes'". This mini-project aimed to spread and build on the good practice identified in that collection of case studies.

Progress files were used by Sheffield Hallam 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. This project aimed to pilot a Sheffield Hallam-style system at Greenwich.

Objectives

To implement the Sheffield Hallam system at Greenwich as a trial to enhance existing procedures.

Outputs

Case study report.

Outcomes

This pilot use concluded that the Sheffield Hallam Progress Files system shows great potential and it will be used even more extensively from next year; in particular it will be made the main channel for students to create their PDP logbooks.

Good practice identified in the Developing Graduate Skills booklet has been spread to another institution. Further, the case for spreading this good practice beyond one institution has been made.

Resources

Mann, T. and Lakin, S., 2012. Progress Files – Greenwich Implementation. *In*: P. Rowlett (ed.), *Further Work Developing Graduate Skills in HE Mathematics Programmes*, pp. 14-15. MSOR Network.

Available via: www.mathcentre.ac.uk/resources/uploaded/FurtherGradSkills.pdf

Enhancing the communication and speaking skills of mathematics undergraduates

This project created a short course on communication skills for mathematics and provided this as a course pack for transfer to other departments.

Project Leader: **James Groves**

Institution: **Lancaster University**

Funding: **Summit outcomes / £5,300**

Collaborators

Gordon Blower, Eileen Cunningham, Lesley Harper, Shamim Khan and Hendryk Korzeniowski, Lancaster University.

Aims

The HE Mathematics Curriculum Summit made a recommendation: "Development of maths-focused resources equivalent to already published generic resources on improving students' communication skills". This project aimed to develop a course to enhance the communication and speaking skills of undergraduate mathematics students, considering these to be distinct from, but closely related to, formal presentation skills.

Objectives

To address the issue of communication skills development highlighted by National Student Survey results by delivering a module in communication and voice skills as an embedded element of a well-established Project Skills course. Emphasis on:

- The communication of ideas through speech;
- The vocal skills needed to speak effectively;
- The verbal description of quantitative data;
- The oral interpretation of diagrams and graphs;
- Engagement with the audience.

To make available the improved provision for others to use.

Outputs

Report on activity.

Course pack providing materials for others to run a similar course.

Outcomes

Employers value these skills and developing them will help students directly with their academic work. The ability to communicate a complex idea is a useful transferable skill, which should assist students' understanding of their work. This project improved the provision at Lancaster and made available the improved provision for others to use.

Having been judged to be very successful, this activity will be repeated at Lancaster in future years using the course materials developed. The department is also considering how other components of the credit-bearing module in skills development can be enhanced in light of this positive experience.

Resources

Groves, J., 2012. Enhancing the communication and speaking skills of mathematics undergraduates. *In*: P. Rowlett, ed., *Further Work Developing Graduate Skills in HE Mathematics Programmes*, pp. 19-22. MSOR Network.

Course pack containing workshop and assessment materials.

Both available via: www.mathcentre.ac.uk/topics/hestem-projects/grad-skills

Teaching Students to Write Mathematics

This project ran a workshop on 'Teaching students to write mathematics' and shared the information presented at that workshop. This provided teaching good practice linked to mathematical thinking and graduate skills.

Project Leader: **Kevin Houston**

Institution: **University of Leeds**

Funding: **Summit outcomes / £1,100**

Collaborators

Contributors: Franco Vivaldi, Queen Mary, University of London; Mike Robinson, Sheffield Hallam University.

Aims

The HE Mathematics Curriculum Summit made a recommendation: "Development of maths-focused resources equivalent to already published generic resources on improving students' communication skills". This project aimed to capture information shared at a workshop on 'Teaching Students to Write Mathematics' for wider dissemination.

The workshop discussed methods to provide mathematics-specific advice on writing skills. Teaching students to write in a more orderly and logical way has numerous advantages, allowing students to more clearly demonstrate their understanding (or not) and forcing 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.

Objectives

To run a workshop.

To record three talks at the workshop and make these available with extra material.

Outputs

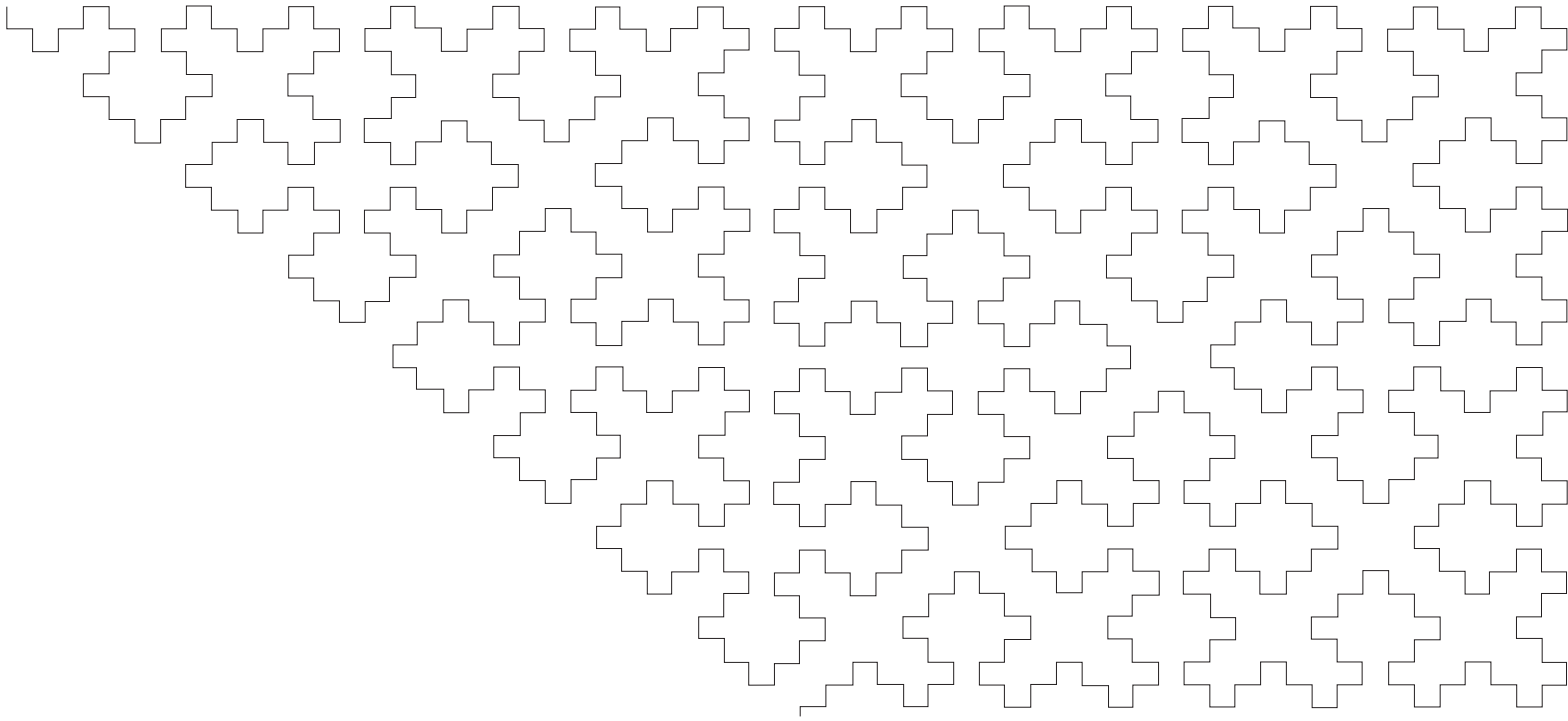
A DVD containing recordings of the workshop sessions as well as the presentation slides, further reading and sample teaching resources was produced and its contents also made available to view online.

Outcomes

Lecturers teaching mathematics have access to techniques and materials to develop their students' mathematical writing skills. Writing clearly is connected to mathematical thinking and graduate skills.

Resources

The DVD can be downloaded and burned to disc, and its contents are available to view online, via: www.kevinhouston.net/dvds/writing-math.html



Engaging with employers

It is important to take account of the needs of employers when developing graduate mathematicians. A majority of students will be looking for employment when they graduate and we should ask ourselves what we are doing to help them. For those that enter further study, the skills we hope for in future researchers are not very different to those employers ask for from graduates.

Some of the projects in this section have worked with employers, employees or professional bodies to develop research findings, good practice advice and curriculum resources to improve graduate skills. Others offer examples of approaches involving employers in delivery of teaching and assessment for work-related learning, and various models that can be used to place students within organisations for work-based learning.

This work is related to the previous section on 'Developing graduate skills' (page 13). Further work on developing curriculum resources in collaboration with employers is given in the next section on 'Industrial problems' (page 31).

Coordination project

Jeff Waldock (Sheffield Hallam University) undertook to coordinate the output from projects in this area to produce a combined booklet in a format that is useful to the community which was printed and distributed (£2,250).

Key Resources

Waldock, J., and Rowlett, P. (eds.), 2012. *Employer Engagement in Undergraduate Mathematics*. MSOR Network.
Available via: www.mathcentre.ac.uk/resources/uploaded/EmployerEngagement.pdf

Inglis, M., Croft, T. and Matthews, J., 2012. *Graduates' Views on the Undergraduate Mathematics Curriculum*. MSOR Network.
Available via: www.mathcentre.ac.uk/resources/uploaded/GradViews.pdf

Mann, T. and Good, C., 2012. *Being a Professional Mathematician*. MSOR Network.
Available via: www.mathcentre.ac.uk/resources/uploaded/BeingAProMathematician.pdf

A Statistical Awareness Curriculum for STEM Employees

This project investigated STEM employers' expectations of their employees' statistical skills and provided materials to audit and address these.

Project Leader: **Neville Davies**

Institution: **Plymouth University**

Funding: **HE Curriculum Innovation / £10,000**

Collaborators

John Marriott, Plymouth University.

Aims

To create a learning environment to raise statistical awareness among STEM employers and employees by:

A. showing the need for employers to audit employees' statistical skills;

B. building an understanding of the role of statistical skills in developing a fully competent workforce;

C. developing an appreciation of how statistical skills can improve productivity, enhance job satisfaction and support career progression.

Objectives

To produce

1. a template for employers to audit statistical skills.
2. a curriculum specification, agreed with employers and professional bodies, for three statistics-related areas that STEM employees should:
   i. know about;
   ii. be able to critically evaluate;
   iii. be able to fully understand or do.
3. an example teaching resource covering one area of the curriculum specification.

Outputs

This project produced an audit questionnaire, a curriculum specification in the three areas and an example teaching resource related to analysis of variance.

Outcomes

This project produced resources to inform the development of statistical awareness and skills in the workforce. Its findings will be taken forward as part of the Royal Statistical Society getstats statistical literacy campaign.

Resources

The audit tool, curricula and exemplar materials are available via the Royal Statistical Society Centre for Statistical Education (RSSCSE) web site www.rsscse-edu.org.uk by following the link to 'A Statistical Awareness Curriculum for STEM Graduate Employees'. A password is required. To obtain this please email admin@rsscse.org.uk.

Davies, N. and Marriott, J., 2012. A Statistical Awareness Curriculum for STEM Employees. *In*: J. Waldock, and P. Rowlett (eds.), *Employer Engagement in Undergraduate Mathematics*, pp. 33-38. MSOR Network.
Available via: www.mathcentre.ac.uk/resources/uploaded/EmployerEngagement.pdf

Davies, N. and Marriott, J., 2012. A Statistical Awareness Curriculum for STEM Employees [full report]. Available via:
www.rsscse.org.uk/images/files/pdf/activities/CaseStudy-STEM-curriculum.pdf

Views of graduates on the HE curriculum

This project surveyed graduates' views on the undergraduate mathematics curriculum to inform current HE practice.

Project Leader: **Matthew Inglis**

Institution: **Loughborough University**

Funding: **Summit outcomes / £6,200**

Collaborators

Tony Croft and Janette Matthews, Loughborough University.

Aims

Interested to seek the views of graduates on their degree programmes, from the perspective of employment, the HE Mathematics Curriculum Summit made a recommendation: "Research to collect the feedback of graduates in employment on the mathematics HE curriculum". This project addressed this recommendation.

Objectives

To understand graduates' perspectives on the undergraduate mathematics curriculum. Specific foci 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.

The instrument will be designed so that it renders findings that are comparable with (a) the HEA Chemistry and Physics project; (b) the MoreMathsGrads survey of incoming MSOR undergraduates; and (c) Inglis's survey of academic mathematicians conducted as part of his Royal Society Fellowship.

Outputs

The survey received 428 responses and a detailed report of findings has been published.

Outcomes

This work contributed to ensuring that the higher education mathematics community keeps pace with developments in the workplace. It provided evidence about the experiences that graduates perceive as useful, and therefore allows higher education institutions to review their own academic provision to ensure that students are provided with skills that will maximise their employability. The community will benefit from resources which address a need identified by the HE Mathematics Curriculum Summit.

As well as these direct outcomes, the project also directly informs a longitudinal project that the Royal Society has commissioned to better understand the cognitive benefits of studying advanced mathematics (http://mec.lboro.ac.uk/mcg/rs/). This is a five-year project which, it is intended, will provide a robust evidence-base to inform future educational policy initiatives.

Resources

Inglis, M., Croft, T. and Matthews, J., 2012. *Graduates' Views on the Undergraduate Mathematics Curriculum*. MSOR Network.

Available via: www.mathcentre.ac.uk/resources/uploaded/GradViews.pdf

Being a professional mathematician

This project produced a set of case studies on working mathematicians and the development of mathematics in history to help develop students' awareness of the practices of being a professional mathematician. The focus was on developing resources that are useful to the HE curriculum and providing advice on how to use these.

Project Leader: **Tony Mann**

Institution: **University of Greenwich**

Funding: **Summit outcomes / £11,000**

Collaborators

Chris Good, University of Birmingham.

Aims

Concerned that an undergraduate student of mathematics would not be able to articulate the working practices of a mathematician, the HE Mathematics Curriculum Summit made a 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". This project addressed this recommendation.

Objectives

To produce a set of case studies on 'being a mathematician'. Some will be historical, some based on interviews with present-day mathematicians (statisticians, OR practitioners) in academia and industry.

To pilot these materials and provide guidance and suggestions as to how they could be incorporated into the undergraduate curriculum.

To organise a workshop for potential users.

Outputs

Audio recordings of interviews, worksheets and other resources were made available.

A report gives details of the resources and example uses that could be made in the undergraduate curriculum.

Outcomes

Lecturers are supported to develop in their students a sense of what it means to be a professional mathematician. The community will benefit from resources which address a need identified by the HE Mathematics Curriculum Summit.

Resources

The curriculum resources developed are available via the website www.BeingAMathematician.org

Mann, T. and Good, C., 2012. *Being a Professional Mathematician*. MSOR Network. Available via: www.mathcentre.ac.uk/resources/uploaded/BeingAProMathematician.pdf

Assessing student teams developing mathematical models in business and industrial mathematics

This project developed and trialled a novel teaching and assessment approach designed to give students experience of business and industrial working practices, involving employers in delivery.

Project Leader: **Edmund Chadwick**

Institution: **University of Salford**

Funding: **HE Curriculum Innovation / £5,000**

Collaborators

Kevin Sandiford and David Percy, University of Salford.

Aims

To develop a teaching approach giving students experience of business and industrial working practices.

To involve employers in the delivery of this curriculum.

Objectives

To develop a teaching approach to allow students to solve practical mathematical problems not through a traditional academic route by examination or essay but by a pro-active approach through a team-based problem-solving format familiar to the world of business and industry, to expose the students to various roles played within a team and assess their preferences, performance and capacity for changing role particularly in the context of developing mathematical models.

To expose students to content delivered by industrial partners.

To involve industrial partners in assessment of student work.

Outputs

An evaluation of this activity was conducted and a report written to share this approach.

Outcomes

A new module based on innovative practice was incorporated into the Salford degree. This module will be embedded in the programme at Salford in future years. A newly developed and evaluated novel approach was made available through a case study to other institutions seeking to improve their curriculum.

Resources

Chadwick, E., Sandiford, K. and Percy, D., 2012. Assessing student teams developing mathematical models applied to business and industrial mathematics. *In*: J. Waldock, and P. Rowlett (eds.), *Employer Engagement in Undergraduate Mathematics*, pp. 41-44. MSOR Network.

Available via: www.mathcentre.ac.uk/resources/uploaded/EmployerEngagement.pdf

Work-related Learning Working Group

How realistic is work-related learning at university, and how realistic should it be? Work-related learning at university often involves using subject matter that is only loosely related to the world of work. Realistic problems quickly require specialism, and consequently it is difficult to find realistic subject matter pitched at an appropriate technical level for the student. In work-related modules, academia often simulates simple (unrealistic) versions of industrial problems. However, there is more to work-related learning than simply attempting an accurate simulation of work-related problems. These issues were explored and presented for dissemination.

Project Leader: **Edmund Chadwick**

Institution: **University of Salford**

Funding: **Working groups / £300**

Collaborators

Jeff Waldock, Sheffield Hallam University; Noel-Ann Bradshaw, University of Greenwich; Louise Orpin, Operational Research Society; David McNulty, University of Salford; Terrance Haydock, University of Central Lancashire; Charlie Ellis, North West Universities Association; Makhan Singh and Nigel Steele, Institute of Mathematics and its Applications.

Aims

To explore issues around realism in work-related learning, establish good practice and disseminate the findings.

Objectives

To detail which parts of work-related learning are realistic and which are not, to assess to what degree and in what form this realism can be achieved and identify the reasons for this.

To arrive at a consensus about which parts of work-related learning benefit from being realistic, and which do not.

To draw guidelines identifying the elements required for good practice in work-related learning.

To write these conclusions up in the form of a good practice guide.

Outputs

A report was publishing giving an account of the issues explored, drawing on various academic and professional body collaborators.

Outcomes

Advice is available to the community on the value of work-related learning and advice on how to achieve this. This report will inform the delivery of work-related learning.

Resources

Chadwick, E. et al., 2012. How realistic is work-related learning, and how realistic should it be? *In*: J. Waldock, and P. Rowlett (eds.), *Employer Engagement in Undergraduate Mathematics*, pp. 47-51. MSOR Network.

Available via: www.mathcentre.ac.uk/resources/uploaded/EmployerEngagement.pdf

Models of industrial placements

This project investigated different approaches to placements, including an innovative approach, to encourage institutions to consider options to support their students through work-based learning.

Project Leader: **Tony Mann**

Institution: **University of Greenwich**

Funding: **Summit outcomes / £2,000**

Aims

The HE Mathematics Curriculum Summit made a recommendation: "Pilot of undergraduate students gaining experiencing of working in industry through short term placements (e.g. 2 hours per week)". As well as a traditional year-long sandwich placement, the University of Greenwich has a new 'Mathematics Industry Placement' 30-credit module taken during final year. This involves short-term placements of the kind recommended by this Summit recommendation so, rather than initiating a new pilot scheme, a mini-project exploring the Greenwich pilot was commissioned.

Objectives

To collect information on various approaches to placements.

To investigate an unusual industrial placements scheme to capture information that would help others considering such a scheme.

To run a workshop and produce a findings report.

Outputs

A report was produced containing information collected on placements provision at various universities, details of different models for placements in industry and schools and the final year project approach.

Outcomes

This activity will assist other institutions in considering how best to support their students through work-based learning. The community will benefit from resources which address a need identified by the HE Mathematics Curriculum Summit.

Resources

Mann, T., 2012. Models of Industrial Placements for Mathematics Undergraduates. *In*: J. Waldock, and P. Rowlett (eds.), *Employer Engagement in Undergraduate Mathematics*, pp. 53-61. MSOR Network.

Available via: www.mathcentre.ac.uk/resources/uploaded/EmployerEngagement.pdf

Supporting progression in mathematics education

Final year maths degree students visited a local secondary school and witnessed first hand the teaching of maths to GCSE and A-level students. They prepared teaching material suitable for GCSE and A-level classes and presented a taught session and associated teaching materials to classes of the appropriate level from the assisting school.

Project Leader: **James Hind**

Institution: **Nottingham Trent University**

Funding: **HE Curriculum Innovation / £1,500**

Collaborators

Wendy Kempster, Anne Hall and Maddy Bayes, Nottingham Girls High School.

Aims

To improve the employability prospects of university students in applying for a career in teaching.

To enable the university to develop experience in working with schools.

To improve the school pupils' perceptions of mathematics and university.

Objectives

To develop a curriculum approach in partnership with a local school to allow final year maths students who have expressed an interest in teaching the chance to experience and explore teaching practice.

Through the student engagement with the school, to dispel some of the myths about a maths education and giving the school pupils insight into the range of possible courses and future careers in mathematics.

To build a partnership between the university and school.

To improve pupil's perceptions of mathematics and university and to portray positive images of mathematics courses and careers to girls.

Whilst the assisting school has an excellent rate of progression to higher education in general, it has a disappointing rate of progression to maths courses; it is hoped that this project will help to rectify this.

Outputs

An evaluation was conducted and shared through a report.

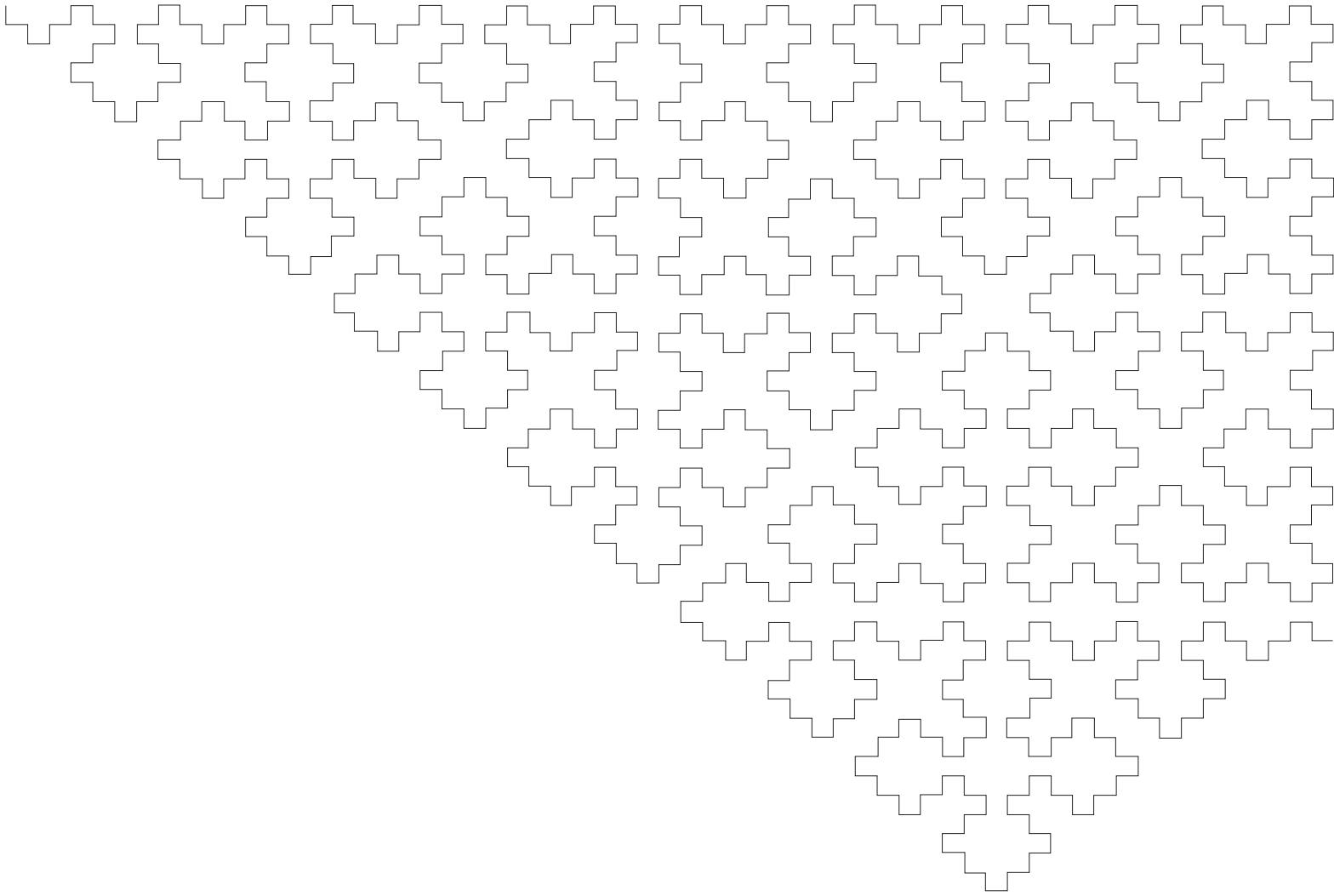
Outcomes

This approach has the potential to simultaneously improve the graduate prospects of university students who are interested in teaching, while engaging school pupils in mathematics activities beyond the curriculum and making them aware of the possibilities offered by mathematics at university. The university built its expertise in working with local schools and engaging students in school teaching practice. This activity will be repeated in future years using this expertise in a modified form following the evaluation of this project. This experience was shared so others can learn from the approach.

Resources

Hind, J., 2012. Supporting progression in mathematics education. *In*: J. Waldock, and P. Rowlett (eds.), *Employer Engagement in Undergraduate Mathematics*, pp. 63-64. MSOR Network.

Available via: www.mathcentre.ac.uk/resources/uploaded/EmployerEngagement.pdf



Industrial problems

Mathematics departments can benefit from real problems drawn from industrial contexts but the process has two main problems: the difficulty of finding and engaging with industrial partners; and, matching the difficulty of projects to undergraduate level. The HE Mathematics Curriculum Summit made a recommendation: “Development of a bank of industry-based problems, suitable for undergraduate students, developed in consultation with industry partners and vetted”.

Two projects aimed to address this recommendation – one in mathematics and one in statistics – by making available banks of real world problems developed in consultation with industrial partners.

The previous section on ‘Engaging with employers’ (page 21) contains reports detailing other aspects of employer involvement with undergraduate mathematics.

Industrial Problem Solving for Higher Education Mathematics

This project drew real world mathematical problems from industrial partners, assessed these for use in the undergraduate curriculum and made them available to the sector.

Project Leader: **Martin Homer**

Institution: **University of Bristol**

Funding: **Summit outcomes / £29,000**

Collaborators

Oscar Benjamin, Jonathan Lawry and Jonathan Rossiter, University of Bristol.

Aims

To develop and vet a bank of industry-based problems in mathematics, suitable for undergraduate students.

Objectives

To create a diverse online repository of industrial case study problems, suitable for use throughout mathematics undergraduate programmes.

Outputs

A wiki website divides projects into three categories: introductory, intermediate and advanced, intended to correspond loosely to the first, second and third years of UK mathematics undergraduate study, with currently around 20 fully documented projects within each level.

Outcomes

The community will benefit from resources which address a need identified by the HE Mathematics Curriculum Summit. Wider availability of real problems from industry, vetted and matched to undergraduate level, will allow universities to offer much richer, industry-led mathematics problems to undergraduate students. The wiki will continue to be developed and is designed to accept new problems from the community.

Resources

The wiki is available via https://wikis.bris.ac.uk/display/ipshe/Home

Access to view these problem briefs is open, where this is possible without compromising problem solutions. Further information is available and you are encouraged to contribute to the problem bank; both can be arranged via contact details given on the site.

A report describing the activity of this project is available:

Benjamin, O., Homer, M., Lawry, J. and Rossiter, J., 2012. Industrial Problem Solving for Higher Education. *In*: J. Waldock, and P. Rowlett (eds.), *Employer Engagement in Undergraduate Mathematics*, pp. 23-25. MSOR Network.

Available via: www.mathcentre.ac.uk/resources/uploaded/EmployerEngagement.pdf

Industrial Problems for the HE Curriculum in Statistics

This project drew real world statistical problems from an industrial partner, assessed these for use in the undergraduate curriculum and made them available to the sector.

Project Leader: **Neville Davies**

Institution: **Plymouth University**

Funding: **Summit outcomes / £10,600**

Collaborators

John Marriott, Plymouth University; Shirley Coleman, Newcastle University.

Aims

To develop and vet a bank of industry-based problems in statistics, suitable for undergraduate students.

Objectives

To 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.

Outputs

Thirteen problem scenarios were made available at three undergraduate levels with many instances of each scenario available via randomly selected data sets. Solutions are available to tutors.

A report describing the resources and detailing their production is available.

Outcomes

The sector will have access to real world problems solvable using data interrogation, graphical and statistical modelling methods from an industrial/business partner, vetted for use with undergraduate students at three levels. The community will benefit from resources which address a need identified by the HE Mathematics Curriculum Summit.

Resources

The problems are available via the Royal Statistical Society Centre for Statistical Education (RSSCSE) web site www.rsscse-edu.org.uk by following the link to ‘Industrial Problems for the HE Curriculum’. A password is required. To obtain this please email admin@rsscse.org.uk.

Davies, N. and Marriott, J., 2012. Industrial problems in statistics for the HE curriculum. *In*: J. Waldock, and P. Rowlett (eds.), *Employer Engagement in Undergraduate Mathematics*, pp. 27-30. MSOR Network.
Available via: www.mathcentre.ac.uk/resources/uploaded/EmployerEngagement.pdf

Davies, N. and Marriott, J., 2012. Industrial problems in statistics for the HE curriculum [full report]. Available via:
www.rsscse.org.uk/images/files/pdf/activities/CaseStudy-STEM-Industrial-Problems.pdf

Problem-solving

A discussion at the HE Mathematics Curriculum Summit noted that confidence when handling problems was a common selling point of mathematics degree courses, and that this is linked to employability because “in many areas of employment, graduates will not be tackling familiar problems, which can often be automated, but will be tackling unfamiliar problems”. Delegates recognised problem-solving as a skill that is used even by graduates who are not using their mathematical skills and, consequently, that “problem-solving is the most useful skill a student can take with them when they leave university”.

However, the Summit session also recognised that “a different approach to teaching” may be required in order to develop “skills and confidence”, “deep understanding” and “adaptability”, and to encourage students to “think creatively for themselves”.

Two Summit recommendations concerned collecting and sharing good practice on problem solving and developing banks of suitable problems. The two projects in this section addressed these recommendations.

The Maths Arcade (page 39) has an aim to develop problem-solving skills and mathematical thinking through use of strategy games and puzzles.

A further Summit recommendation concerned developing teaching resources to aid in students’ understanding of the process of doing mathematics. A project based on this recommendation is ‘Being a professional mathematician’ (page 24).

Key Resources

Badger, M.S., Sangwin, C.J. and Hawkes, T.O., 2012. *Teaching Problem-solving in Undergraduate Mathematics*. Coventry University.
Available via: www.mathcentre.ac.uk/problemsolving

MaPS: Mathematical Problem-solving Project

This project investigated work on problem-solving in HE mathematics and shared current good practice. It also created a bank of problems and solutions. This provided resources to show the value of problem-solving and make it easier for lecturers to incorporate problem-solving meaningfully into teaching and assessment.

Project Leader: **Trevor Hawkes**

Institution: **Coventry University**

Funding: **Summit outcomes / £36,500**

Collaborators

Matthew Badger, Coventry University; Chris Sangwin, University of Birmingham; John Mason, Open University; Bob Burn, Exeter University; Joe Kyle (evaluator).

Aims

The HE Mathematics Curriculum Summit made recommendations to collect good practice on problem-solving and develop a bank of problems. This project aimed to address these recommendations.

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 their 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.

Objectives

Consult widely in HE; carry out case studies; write a good practice guide; create problem banks with solutions; examine the role of mathematical software in problem-solving. Work where possible in collaboration with the other Problem-solving project (see page 37).

Outputs

A collection of case studies and good practice advice was published.

A website hosts a bank of problems.

Outcomes

The good practice advice and guidance on incorporating problem-solving meaningfully into the curriculum together with the problem bank will enable universities to address the key skill of problem-solving in their teaching, learning and assessment. The community will benefit from resources which address a need identified by the HE Mathematics Curriculum Summit.

Resources

Badger, M.S., Sangwin, C.J., Hawkes, T.O., 2012. *Teaching Problem-solving in Undergraduate Mathematics*. Coventry University.

Project website containing a bank of problems.

Both available via: www.mathcentre.ac.uk/problemsolving

PSUM: Problem-Solving in Undergraduate Mathematics

This project designed and developed a problem-solving package to support HE colleagues in embedding problem-solving into their courses, particularly through a virtual problem-solving environment and case studies of effective integration of problem-solving into courses.

Project Leader: **Sue Pope**

Institution: **University of Manchester**

Funding: **Summit outcomes / £20,000**

Collaborators

Nick Almond and Anesa Hosein, Liverpool Hope University; Lynne McClure, NRICH, University of Cambridge.

Aims

The HE Mathematics Curriculum Summit made recommendations around enabling embedding of problem-solving in the HE curriculum. This project aimed to address these recommendations by developing a virtual problem-solving package.

Objectives

To develop an innovative and sustainable online bank of starting points for problem-solving, presented in an interactive, visual and engaging way that will nurture mathematical thinking, logical processes and modelling.

To contribute to the guide for incorporating problems into courses, developing problem-solving skills and assessment and providing case studies of effective integration of problem-solving into undergraduate mathematics courses, in collaboration with the other Problem-solving project (see page 36).

Outputs

Four starting points for problem-solving, named *interactivities*, have been designed, developed and tested.

A report describing the resources and detailing their production is available.

Outcomes

The virtual problem-solving environment was designed to enable its continued development as a repository for problems that can be used by tutors of undergraduate mathematics. The community will benefit from resources which address a need identified by the HE Mathematics Curriculum Summit.

Resources

Pope, S., 2012. Problem-solving and Computer-aided Learning. In: M.S. Badger, C.J. Sangwin, and T.O. Hawkes. *Teaching Problem-solving in Undergraduate Mathematics*. Coventry University. Available via: www.mathcentre.ac.uk/problemsolving

The four interactivities will be available from September 2012 via the NRICH website at nrich.maths.org/psum

Maths Arcade

The Maths Arcade aims to stretch the most able students and those who have more prior mathematical knowledge, whilst at the same time supporting those with weaker backgrounds or who take a little longer to grasp mathematical concepts.

At the University of Greenwich, Noel-Ann Bradshaw established the first Maths Arcade, providing a venue for mathematical talk, games and problem-solving, with a range of strategy board games and puzzles available which are designed to hone and develop strategic thinking. This also aims to encourage staff/student interaction, with academic staff attending and students getting help with tutorial work from peers or staff.

Originally funded through a grant from the University of Greenwich, support was provided to expand the scale and remit of the Maths Arcade, promote this to other disciplines and roll this out to other universities. Two projects in this section cover the enhanced Maths Arcade at Greenwich and the project to expand this to seven other universities.

The section on problem-solving (page 35) contains projects aiming to develop teaching, learning and assessment of problem-solving skills.

Key Resources

Bradshaw, N., Parrott, K., Lakin, S., Mann, T. and Sharp, M., 2012. Building on the Maths Arcade: supporting mathematics learning. *In*: C. Robinson (ed.), *Student-centred Approaches in Mathematics*. MSOR Network.
Available via: www.mathcentre.ac.uk/resources/uploaded/Studentcentred.pdf

Bradshaw, N. and Rowlett (eds.), 2012. *Maths Arcade: stretching and supporting mathematical thinking*, MSOR Network.
Available via: www.mathcentre.ac.uk/resources/uploaded/MathsArcade.pdf

Building on the Maths Arcade: supporting mathematics learning

The Maths Arcade aims to stretch more confident students and support those who are struggling, and to encourage interaction between students and with staff outside of the curriculum. This project developed and enhanced the Maths Arcade provision at Greenwich and provided the guidance needed to transfer this novel practice to other institutions.

Project Leader: **Noel-Ann Bradshaw**

Institution: **University of Greenwich**

Funding: **Transfer of proven innovative practice / £5,000**

Collaborators

Tony Mann, Steve Lakin, Kevin Parrott and Mike Sharp, University of Greenwich.

Aims

To extend and increase the Maths Arcade provision. This will particularly take the provision beyond transition support and social interaction to encourage the students more explicitly to engage with analysing the games mathematically.

To make information on the provision available to encourage uptake elsewhere.

Objectives

To provide a bigger range of games and puzzles, and to broaden the access to the Arcade. In co-operation with the School of Engineering, to stimulate similar Maths Arcade activities on that campus for Science and Engineering students.

To train staff and postgraduate students to use these props in outreach activities and to allow extended Maths Arcade opening hours.

To evaluate the provision and provide guidance on setting up and running a Maths Arcade.

Outputs

Papers giving the staff and student view of the Maths Arcade were published. A guide to starting a Maths Arcade was published. A final report evaluating this activity and drawing lessons from a comparison of the first and second years of this activity was published.

Outcomes

An enhanced Maths Arcade is in place at Greenwich.

The information shared allows others to consider this initiative and understand how to implement it.

The Maths Arcade can provide an enhanced learning experience for students, leading to improved retention and better achievement. By promoting peer support and encouraging students to talk and think about mathematics outside the classroom this activity helps students gain confidence in their mathematical ability.

Resources

Bradshaw, N., 2011. The University of Greenwich Maths Arcade. *MSOR Connections*, 11(3), pp. 26-29.
Available via: www.mathcentre.ac.uk/resources/uploaded/MSORConnections113.pdf
Carpenter, N., 2011. The University of Greenwich Maths Arcade – student view. *MSOR Connections*, 11(3), p. 30.
Available via: www.mathcentre.ac.uk/resources/uploaded/MSORConnections113.pdf
Bradshaw, N., Parrott, K., Lakin, S., Mann, T. and Sharp, M., 2012. Building on the Maths Arcade: supporting mathematics learning. *In*: C. Robinson (ed.), *Student-centred Approaches in Mathematics*. MSOR Network.
Available via: www.mathcentre.ac.uk/resources/uploaded/Studentcentred.pdf
Bradshaw, N., 2012. Maths Arcade start-up guide. *In*: N. Bradshaw and P. Rowlett (eds.), *Maths Arcade: stretching and supporting mathematical thinking*, MSOR Network.
Available via: www.mathcentre.ac.uk/resources/uploaded/MathsArcade.pdf

Maths Arcade Uptake Programme

This project spread the good practice identified through the Maths Arcade project at the University of Greenwich to seven other universities and made the case for further adoption elsewhere. It encouraged sustainable takeup and developed a user community.

Project Leader: **Noel-Ann Bradshaw**

Institution: **University of Greenwich**

Funding: **Maths Arcade Uptake Programme / £11,000**

Collaborators

Edmund Chadwick, University of Salford; Claire Cornock and Erik Baxter, Sheffield Hallam University; Jeremy Levesley, University of Leicester; David Bedford, Keele University; Emma Cliffe and Jane White, University of Bath; Louise Walker, University of Manchester; Sally Barton, University of Nottingham.

Aims

To encourage and support the takeup of good practice identified at the University of Greenwich through its Maths Arcade project

Objectives

To support the takeup of Maths Arcade provision at other universities.

Consequently:

to make the case for this transfer of good practice more widely;

to build a community of Maths Arcade users.

Outputs

This project provided full funding for Maths Arcades at Salford, Keele, Sheffield Hallam and Leicester, partial funding for university Maths Arcade initiatives at Bath and Manchester and links to a wider community for one Maths Arcade fully-funded by the University of Nottingham. Training and coordinated evaluation were made available to all seven new Arcades.

A set of case studies from the seven new Maths Arcades was produced.

Outcomes

Sustainable provision was created at the partner universities.

Maths Arcade has been established as good practice that is suitable for transfer to other universities. The case studies show the Maths Arcade idea adapted to various different local scenarios and should provide plenty of evidence and examples of use for others to consider adopting. An active user group is available to encourage further adoption.

Resources

Bradshaw, N. and Rowlett (eds.), 2012. *Maths Arcade: stretching and supporting mathematical thinking*, MSOR Network.
Available via: www.mathcentre.ac.uk/resources/uploaded/MathsArcade.pdf

Find out about the Maths Arcade user group via www.ima.org.uk/viewItem.cfm?cit_id=384191

Student-centred Approaches

Work reported in this section has as its common theme the development of approaches which particularly take into account the needs of students.

First, a project provides individual support for students of other disciplines using statistics via an online one-to-one advice service. Two projects encourage engineering students' understanding and ability in mathematics.

Three projects consider the needs of disabled students and others and developing inclusive curricula practices to accommodate these needs. These make available general good practice advice, develop resources for producing accessible learning resources in mathematics and provide good practice advice on group work.

Finally, a project on using the history of mathematics investigates how students can be engaged with mathematics through use of history in the curriculum.

Coordination project

Carol Robinson (Loughborough University) undertook to coordinate the output from projects in this area and produced a combined booklet in a format that is useful to the community which was printed and distributed (£2,250).

Key Resources

Robinson, C. (ed.), 2012. *Student-centred Approaches in Mathematics*. MSOR Network. Available via: www.mathcentre.ac.uk/resources/uploaded/Studentcentred.pdf

McCartney, M. (ed.), 2012. *History of Mathematics in the Higher Education Curriculum*. MSOR Network. Available via: www.mathcentre.ac.uk/resources/uploaded/HistoryofMaths.pdf

Owen, A., Samuels, P., Wrightham, M., Leckenby, B. and Gilchrist, M., 2011. *A Pilot for a Shared Online Statistics Advisory Service*. Loughborough University.
Available via: www.mathcentre.ac.uk/resources/uploaded/SharedSAS.pdf

A Pilot for a Shared On-line Statistics Advisory Service

Some HE institutions provide an appointments-based Statistics Advisory Service (SAS) targeted at final year and postgraduate students across STEM disciplines. However, many HE institutions do not provide a SAS, possibly due to lack of statistically qualified personnel, financial resources or direct evidence of demand. Where resourcing is an issue, an alternative that institutions could consider is a shared SAS resource, provided via an on-line learning space. This project piloted such a shared SAS resource, in order to assess the practical and pedagogical issues involved, and the potential demand for such a service.

Project Leader: **Alun Owen**

Institution: **Loughborough University**

Funding: **HE Curriculum Innovation / £5,000**

Collaborators

Michele Wrightham, De Montfort University; Bernadette Leckenby, University of Sunderland; Peter Samuels, Birmingham City University; Mollie Gilchrist, Loughborough University.

Aims

To assess the practical and pedagogical issues involved in providing an appointments-based Statistics Advisory Service via an on-line learning space.

To assess the potential demand for such a service.

Objectives

To pilot and evaluate a scheme whereby HE institutions without a dedicated SAS can provide an appointments-based Statistics Advisory Service to final year project students and postgraduate students across STEM disciplines through an on-line service which is shared with other HE institutions.

Outputs

The project facilitated a total of 68 appointments via an online learning space/web meeting tool taken up by 46 students from the three partner institutions.

A short findings paper was published in *MSOR Connections*.

A full report giving details of the pilot study and its findings is available.

Outcomes

The pilot study 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. The information made available could be used by HE institutions to inform their decision about whether and how to provide such a service in the future.

Resources

Owen, A., Samuels, P., Wrightham, M., Leckenby, B. and Gilchrist, M., 2012. A Pilot for a Shared Online Statistics Advisory Service. *In*: C. Robinson (ed.), *Student-centred Approaches in Mathematics*. MSOR Network.
Available via: www.mathcentre.ac.uk/resources/uploaded/Studentcentred.pdf

Owen, A., Samuels, P., Wrightham, M., Leckenby, B. and Gilchrist, M., 2011. *A Pilot for a Shared Online Statistics Advisory Service*. Loughborough University.
Available via: www.mathcentre.ac.uk/resources/uploaded/SharedSAS.pdf

Engineering Students Understanding Mathematics (ESUM) – An innovative teaching approach with integrated research

This project worked to enhance participation and understanding of engineering students in mathematics, through group engagement with mathematical software, and to study outcomes. This pioneered an innovative methodology towards developing teaching and the design of teaching with first year Materials Engineering students but its focus is generic; the findings are expected to influence design of teaching broadly within Loughborough University and beyond.

Project Leader:	**Barbara Jaworski**
Institution:	**Loughborough University**
Funding:	**HE Curriculum Innovation / £5,000 (£2,500 provided by MSOR and £2,500 provided by the Royal Academy of Engineering)**

Collaborators

Carol Robinson, Tony Croft and Janette Matthews Loughborough University.

Aims

To develop/improve participation and mathematical understanding of first year engineering students through innovation in practice and to study outcomes.

Objectives

To work closely with engineering subject areas and develop links between mathematics teachers and engineers.

To use a developmental research approach and evaluate its contribution to the teaching process and to students' participation and understanding.

To evaluate the contribution made by mathematical software and a pedagogic approach of grouping students for activity and assessment.

To disseminate outcomes to colleagues in both mathematics and engineering both in and beyond Loughborough University.

Outputs

The course was delivered as planned and evaluated.

A report was prepared sharing the findings.

Outcomes

Compared with previous cohorts a much greater engagement in lectures was observed. Marks in tests and examinations were at a higher level (approximately 10%) than in previous years. The overwhelmingly positive outcome from ESUM is what the project team have learned as teachers about what engaged students and how they experienced the innovative approaches used. The project team are 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.

Resources

Jaworski, B., Matthews, J., Robinson, C. and Croft, T., 2012. Engineering Students Understanding Mathematics (ESUM). *In*: C. Robinson (ed.), *Student-centred Approaches in Mathematics*. MSOR Network.
Available via: www.mathcentre.ac.uk/resources/uploaded/Studentcentred.pdf

Supporting Undergraduate Engagement & Achievement in STEM Disciplines

This project developed an improved mathematics bridging programme for incoming engineering students to increase uptake of engineering at HE.

Project Leaders: **Alexandra Shukie and Melissa Conlon**

Institution: **University Centre at Blackburn College**

Funding: **HE Curriculum Innovation / £5,000**

Collaborators

Dave Kiddell and Nigel Thomson, University Centre at Blackburn College.

Aims

Potential learners are being lost from STEM subjects due to their lack of practical mathematics skills i.e. not due to lack of competence or understanding. Current bridging programmes are not contextualised to engineering & the format of these programmes is neither innovative nor engaging e.g. requiring traditionally taught sessions over a significant period of time prior to commencing the HNC/D or FD course.

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

Objectives

To develop a blended learning approach to the teaching and learning aspect of the bridging programme by developing provision which is contextualised, interactive & available across a variety of media. The result being an engaging programme of learning which significantly moves away from the traditional 'talk & chalk' approach to mathematics delivery.

Outputs

An approach was developed and evaluated. A final report was written to share the findings.

Outcomes

Feedback from students was positive. The project team anticipate that this blended learning approach for delivery of the Mathematics bridging programme will result in increased engagement numbers, widen participation & ultimately contribute to increased success rates (not only on the bridging programme but also on the subsequent HNC/D or FD).

Resources

Shukie, A., Kiddell, D., Thomson, N. and Conlon, M., 2012. Supporting Undergraduate Engagement and Achievement in STEM Disciplines. *In*: C. Robinson (ed.), *Student-centred Approaches in Mathematics*. MSOR Network.
Available via: www.mathcentre.ac.uk/resources/uploaded/Studentcentred.pdf

Good Practice on Inclusive Curricula in the Mathematical Sciences

Courses with substantial mathematical content pose specific accessibility challenges beyond those usually considered in generic inclusive curricula good practice advice. This project worked with different stakeholders involved in supporting mathematics students at HE to investigate and share current good practice relating to inclusive curricula in mathematical sciences.

Project Leader: **Emma Cliffe**

Institution: **University of Bath**

Funding: **HE Curriculum Innovation / £2,200**

Collaborators

Contributions from: Robin Williams, University of Exeter; Nicola Martin, London School of Economics and Political Science; Clare Trott, Loughborough University; David Spybey, New College Worcester; Emma Rowlett, University of Nottingham; Peter Rowlett, Nottingham Trent University; Martyn Cooper and Jonathan Fine, Open University; Alastair Irving, University of Oxford; Steven D. Webb, University of Strathclyde.

Aims

To investigate and share good practice relating to inclusive curricula in mathematical sciences. This will complement and extend, rather than replace, generic good practice advice.

To be a step towards the goal of different stakeholders – academic staff, professional support staff, disability researchers and students – working together to develop inclusive curricula.

Objectives

To run a workshop and publish a booklet based on this of inclusive curricula practice in mathematical sciences.

To encourage contributions from the different stakeholders.

In order to produce a practical document, in addition to raising awareness of key questions, contributors to be asked to provide a context, identify potential barriers and give clear recommendations.

Outputs

The workshop took place. A booklet was published containing reports arising from the workshop.

Outcomes

The booklet will allow the mathematics HE community and others involved in supporting mathematics students in HE to be better informed about potential barriers and good practice in resolving these. Initial feedback from readers has been extremely positive. A better prepared community will reduce the barriers to entry which may cause students to not progress in HE. Different stakeholders will be encouraged to work together to develop these issues.

Resources

Cliffe, E. and Rowlett, P. (eds.), 2012. *Good Practice on Inclusive Curricula in the Mathematical Sciences*. MSOR Network.
Available via: www.mathcentre.ac.uk/resources/uploaded/InclusiveCurricula.pdf

Methods to produce flexible and accessible learning resources in mathematics

A curriculum barrier for students with disabilities is the delivery of mathematical learning resources such as lecture notes, problem sheets and solutions in inaccessible formats. This project investigated this topic and provided guidance to allow a more accessible approach based on proactive adjustments.

Project Leaders: **Jane White and Emma Cliffe**

Institution: **University of Bath**

Funding: **HE Curriculum Innovation / £8,500**

Collaborators

Various member institutions in sigma-sw.

Aims

Individual lecturers may not have the requisite knowledge to produce flexible learning materials containing mathematics. The current practise, both at Bath and elsewhere, of re-typesetting notes in order to produce particular formats for individual needs is expensive in the long run. Whether using LaTeX, Word or MathML based methods the lecturer may find it challenging to produce a single master version from which a variety of accessible formats can be produced.

This project investigated this challenge and provided guidance to allow a more accessible approach.

Objectives

To undertake a literature review to establish the full range of formats a lecturer may need to produce.

To develop methods by which a single master may be used to produce such formats and to evaluate the use of such methods and the formats produced from them.

To challenge the customary practise of delivering the curriculum through the use of inflexible learning resources which require costly reactive adjustments.

In order to enable departments to cost in such proactive adjustments to curriculum delivery, to provide an analysis of the costs, remaining barriers and risks involved.

Outputs

Methods were explored and evaluated. Various reports and exemplars were made available to detail the findings. A summary report was published.

Outcomes

The information provided by this project will: reduce costs of production and maintenance of materials to individual institutions; increase knowledge and expertise of staff who produce and advise on the production of learning materials in the mathematical sciences; and, ensure sustainable access for students with a range of disabilities to formats which suit their needs.

The information provided will enable departments to take a transparent approach to delivering an accessible mathematical curriculum. Thus departments will be able to make proactive adjustments, to communicate realistic expectations to prospective entrants and any limitations under which they may be working to disability advisers and the wider institution.

This will address barriers that currently affect the ability of some students to access any mathematical syllabus at higher level.

Resources

Cliffe, E. and White, J., 2012. Methods to produce flexible and accessible learning resources in mathematics. *In*: C. Robinson (ed.), *Student-centred Approaches in Mathematics*. MSOR Network. Available via: www.mathcentre.ac.uk/resources/uploaded/Studentcentred.pdf

Project website with detailed reports and exemplars: www.bath.ac.uk/study/mash/maths-access

Group Work Working Group

This working group looked at the advantages and disadvantages of group work used in mathematics degree programmes especially in relation to students with Asperger Syndrome (AS). Students with AS can encounter difficulties engaging with group work and this can provide a barrier to accessing the benefits that group work can deliver, particularly in terms of graduate/ employability skills development.

Project Leader: **Noel-Ann Bradshaw**

Institution: **University of Greenwich**

Funding: **£1,300**

Collaborators

Emma Cliffe, University of Bath.

Aims

To build a community of academics that use group work for assessment and developing graduates' skills.

To survey current ideas and practices in group work with a view to disseminating our findings to the wider community.

To inform the community concerning the problems faced by students with AS so that there will be a greater understanding of the problems these students face.

Although generic good practice guidance exists in relation to students with AS, this does not take into account specific problems encountered in mathematical subjects, as highlighted by the workshop and booklet 'Good Practice on Inclusive Curricula in the Mathematical Sciences' (see p. 47). This project aimed to bring together a group of mathematics academics to build discipline specific expertise and good practice.

Objectives

To invite interested academics to attend one of two meetings organised by this project. These meetings will consist of invited talks and times for discussion.

To produce a report of the findings.

Outputs

Two meetings took place and a report was published to share the findings.

Outcomes

A greater knowledge of the benefits and weaknesses of group work and a stronger awareness of the difficulties faced by students with AS.

University mathematics departments have an increased understanding of the issues affecting the dynamics of group work.

Staff are better equipped to develop curriculum approaches which assist students (including those with AS) in overcoming the barriers to engaging with group work.

Resources

Cliffe, E. and Bradshaw, N., 2012. Autism spectrum disorders and group work in mathematics. *In*: C. Robinson (ed.), *Student-centred Approaches in Mathematics*. MSOR Network. Available via: www.mathcentre.ac.uk/resources/uploaded/Studentcentred.pdf

History of Mathematics in the Higher Education Curriculum Working Group

The history of mathematics can be used to motivate undergraduate mathematicians. There is evidence that many learners react positively to examples showing the human factors behind mathematical discoveries. They gain confidence when they realise that the mathematics they are being taught was once new, and that even the greatest mathematicians of the past made mistakes and went down blind alleys. Particularly for students from non-traditional backgrounds, who particularly lack confidence when they arrive in HE, history can help engagement and enhance learning. This project provided guidance on ways in which history can be used in the undergraduate curriculum. It was supported by The British Society for the History of Mathematics (BSHM).

Project Leader: **Tony Mann**

Institution: **University of Greenwich**

Funding: **Working groups / £2,250**

Collaborators

Snezana Lawrence, Bath Spa University; Mark McCartney, University of Ulster; Robin Wilson, Pembroke College, Oxford; Noel-Ann Bradshaw, University of Greenwich; Colva M Roney-Dougal, University of St Andrews; Luke Hodgkin, King's College, London; Bob Burn, Exeter University; Maurice O'Reilly, St Patrick's College Drumcondra, Dublin; The British Society for the History of Mathematics (BSHM).

Aims

To increase awareness of the potential of the use of history of mathematics in supporting undergraduate mathematical learning.

To make lecturers aware of the potential value of historical information, examples and case studies in motivating students and promoting engagement.

To provide guidance on available resources.

Objectives

To convene a working party.

To prepare a report suggesting ways in which the history of mathematics can be used in the HE mathematics curriculum, and suggesting appropriate easily-available resources.

To disseminate this report.

Outputs

A report was published providing guidance, case studies and suggested resources.

Outcomes

Greater awareness of the potential value of using the history of mathematics in undergraduate teaching. Greater confidence for lecturers in their ability to include historical examples. This will lead to greater motivation in some students, improved engagement and retention, and enhanced student achievement.

This working party will be maintained by BSHM who will provide the necessary resources for at least one meeting each year after the conclusion of the project. The ongoing working party will continue to promote these objectives and will disseminate resources and provide a forum for sharing ideas.

Resources

McCartney, M. (ed.), 2012. *History of Mathematics in the Higher Education Curriculum*. MSOR Network. Available via: www.mathcentre.ac.uk/resources/uploaded/HistoryofMaths.pdf

Assessment

A discussion at the HE Mathematics Curriculum Summit on confidence with unfamiliar problems discussed whether current assessment methods "may encourage rote learning, which doesn't encourage deep understanding and adaptability to unfamiliar problems". A talk by Professor Jeremy Levesley expanded on the theme of assessment and the efficiency, validity and variety of assessment methods used in HE mathematics. The Summit noted that a variety of assessment approaches may improve the student experience but the evidence for alternative approaches is limited and not well known.

The Summit made recommendations to review existing theory of assessment, collect examples of good practice on use of different assessment methods for mathematics, explore alternative approaches to assessment and provide teaching resources and support for lecturers. These themes were developed in a major research project, MU-MAP: Mapping University Mathematics Assessment Practices, described in this section.

Also in this section is a project looking to further develop a well established computer-aided assessment system and make it available for wider use, in order to improve provision across STEM.

Key Resources

Iannone, P. and Simpson, A., eds. (2012). *Mapping University Mathematics Assessment Practices*. University of East Anglia. Available via www.uea.ac.uk/edu/mumap

Greenhow, M., Zaczek, K. and Kamavi, A., 2011. Development and integration of computer-aided assessment of discrete mathematics. *MSOR Connections*, 11(3), pp. 31-34. Available via: www.mathcentre.ac.uk/resources/uploaded/MSORConnections113.pdf

MU-MAP: Mapping University Mathematics Assessment Practices

This project detailed existing assessment practice, identified variance and examples of good practice and, particularly, explored how change is implemented. This provided information to support decisions on the range of assessment methods used in HE mathematics.

Project Leader: **Paola Iannone**

Institution: **University of East Anglia**

Funding: **Summit outcomes / £50,000**

Collaborators

Adrian Simpson, Durham University; Oana Radu, University of East Anglia; Ian Jones, Lara Alcock, Carol L. Robinson, Paul Hernandez-Martinez and Stephen Broughton, Loughborough University; Edmund Chadwick, University of Salford; Timothy J. Hetherington, Nottingham Trent University; Stephen J. Garrett, University of Leicester; Paul Hewson and David Graham, Plymouth University.

Aims

This project aimed to address the Summit recommendations to review existing theory of assessment, collect examples of good practice on use of different assessment methods for mathematics, explore alternative approaches to assessment and provide teaching resources and support for lecturers.

Objectives

To survey summative assessment practices across university mathematics and develop resources to share good practice. 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.

The project had a number of key foci: a comprehensive review of the literature; a survey of existing practice; identification of good practice; detailed examples of the costs and effects of change.

Outputs

Main items from a comprehensive review of the academic and professional literature on assessment in mathematics at the university level, findings from a survey of existing practice, case studies of alternative assessment methods and reports from seven mini-projects are presented in a publication.

Summaries of key papers are available as a searchable database via the website.

Outcomes

The outputs may be used to match course and module aims to assessment methods, understand the relationship between content, learning and assessment and, where needed, develop strategic plans for future assessment policies. The training of new lecturers can draw on the materials to add a much needed evidence-based and subject-specific focus on assessment at this level. Established mathematics lecturers can examine their own assessment practice in the light of their peers' work and get a clear understanding of the practical issues involved in undertaking change in their practice. The community will benefit from resources which address a need identified by the HE Mathematics Curriculum Summit.

Resources

Iannone, P. and Simpson, A., eds. (2012). *Mapping University Mathematics Assessment Practices*. University of East Anglia.

Literature library.

Both available via www.uea.ac.uk/edu/mumap.

Development and integration of computer-aided assessment of discrete mathematics

This project extended and exploited computer-aided assessments in elementary discrete mathematics (sets, logic, graph theory). These questions were written in Questionmark's Perception version 3 CAA system and exploit random parameters throughout, including very full feedback and diagrams, thereby generating thousands of rich questions that form an effective learning resource. This question database therefore forms an effective test case for translation into a more useful format, thereby enabling wider delivery via the web.

Project Leader: **Martin Greenhow**

Institution: **Brunel University**

Funding: **HE Curriculum Innovation / £5,000**

Collaborators

Kinga Zaczek and Abdulrahman Kamavi, Brunel University.

Aims

To extend a set of CAA resources used as part of the Foundations of IT programme that seeks to widen participation in STEM.

To understand how the Mathletics CAA package can be made more widely available.

Objectives

To edit/extend existing CAA in discrete mathematics based on 3 years of use.

To evaluate the extended materials.

To make these available to those without access to an out-of-date, propietary software package.

To provide a test case for wider transfer of Mathletics CAA materials into a new, more available system.

Outputs

The goal of developing graph theory questions was met in full.

The maths e.g. system, developed under another project, forms an excellent delivery mechanism for the graph theory questions despite their complexity and rich content including MathML and SVG.

maths e.g. is hosted by Mathcentre which should ensure sustainable long term availability.

A report on this work was presented in *MSOR Connections*.

Outcomes

An enriched STEM student experience at Brunel, including widening participation to STEM from those without mathematics beyond GCSE.

Proven, effective CAA materials made more widely available to other institutions.

A test case to allow transfer of further materials from the Mathletics system to wider use. Building on this, the maths e.g. application now hosts most of the 2000 original Mathletics questions.

Resources

Greenhow, M., Zaczek, K. and Kamavi, A., 2011. Development and integration of computer-aided assessment of discrete mathematics. *MSOR Connections*, 11(3), pp. 31-34. Available via: www.mathcentre.ac.uk/resources/uploaded/MSORConnections113.pdf

maths e.g. can be accessed through mathcentre via: www.mathcentre.ac.uk:8081/mathseg

Audio-visual media in teaching and learning

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.

As well as lectures, recordings can be made of supplementary materials such as worked examples and solutions. Recordings can also bring experiences into teaching that would not ordinarily be possible and make available an innovative alternative form of assessment.

Finally, video recordings can be easily made available for free online, perhaps as open educational resources (OER). This allows content to be brought into teaching and learning from external sources.

However, the availability of such technology does raise questions about whether it can be used effectively to support student learning. The projects in this section explore this emerging area of practice.

Key Resources

Rowlett, P. (ed.), 2012. *Media Enhanced Teaching and Learning: case studies and evidence of effective use*. MSOR Network.
Available via: www.mathcentre.ac.uk/resources/uploaded/METALbooklet.pdf

METAL: Media Enhanced Teaching and Learning

This project explored methods of recording lectures and supplementary material and using recordings in teaching and learning, providing advice on effective approaches in this area of emerging practice.

Project Leader: **Joel Feinstein**

Institution: **University of Nottingham**

Funding: **HE Curriculum Innovation / £2,100**

Collaborators

Claire Chambers, Sally Hanford, Nicki Keating, and Michèle Clarke, University of Nottingham; Mark McCartney, Ulster; Paul Hernandez-Martinez, Loughborough; Rob Kearsley Bullen, Nottingham Trent University; Alexandra Shukie, University Centre at Blackburn College; Birgit Loch, Swinburne University of Technology (Australia); Tony Croft, Loughborough University; Olivia Gill, University of Limerick (Ireland).

Aims

To explore emerging good practice around use of media such as lecture screencasts in delivery of mathematics and other content.

To build a community of users around this technology.

Objectives

To support a series four workshops at the University of Nottingham as part of the existing Media Enhanced Teaching and Learning (METAL) Project and to make these available as national workshops.

Outputs

Some recordings from the workshops have been made available.

A report giving contributions on various aspects of using media to enhance teaching and learning was published.

Outcomes

Attendees at the workshops and those who have watched the recordings or consulted the booklet will have explored this emerging area of good practice and this should encourage the takeup of such an innovative approach in mathematics HE curriculum.

Resources

Rowlett, P. (ed.), 2012. *Media Enhanced Teaching and Learning: case studies and evidence of effective use*. MSOR Network.
Available via: www.mathcentre.ac.uk/resources/uploaded/METALbooklet.pdf

Recordings of workshops are made available via explainingmaths.wordpress.com.

The Internet Librarian and Curator for Mathematics Videos

Confronted with the huge unstructured collection of instructional mathematical videos now on the internet, it is hard for students to find what they are looking for and then to know whether it is relevant and reliable. This small-scale, proof-of-concept pilot project created guidelines for evaluating videos and took the first steps to creating an online portal giving access to a selection of recommended mathematics video tutorials.

Project Leader: **Trevor Hawkes**

Institution: **Coventry University**

Funding: **HE Curriculum Innovation / £5,000**

Collaborators

University of Leicester.

Aims

To start the process of assisting students and lecturers in dealing with the overwhelming choice of instructional mathematical videos.

Objectives

Focusing on a single limited topic (first-order ordinary differential equations), to organise the available instructional mathematical videos into a structured and annotated repository that is quickly accessible through a user-friendly interface. To target first-year undergraduates studying a number of STEM disciplines.

To provide a framework to engage users in critically reviewing and adding to the resources so that the collection gains in authority and becomes more comprehensive over time.

Interesting research questions include:

1. How to catalogue and tag instructional videos effectively

2. How to evaluate their educational value and technical quality

3. How to moderate and validate user contributions

Outputs

A framework for evaluation of mathematics tutorial videos.

A set of evaluated videos on first-order ordinary differential equations.

A website to present the evaluated videos.

Outcomes

An authenticated library of good learning materials will add significant value to the world wide web as a teaching and learning resource for mathematics students in their learning and lecturers in preparing and supplementing their teaching.

Information about how to evaluate the educational and technical quality of instructional mathematical content and structure these with user contributions will inform future efforts.

Resources

Hawkes, T., 2012. The Internet Librarian and Curator of Mathematics Videos. *In*: P. Rowlett (ed.), *Media Enhanced Teaching and Learning: case studies and evidence of effective use*, pp. 40. MSOR Network. Available via: www.mathcentre.ac.uk/resources/uploaded/METALbooklet.pdf

Hawkes, T., 2012. A Framework for the Evaluation of Videos Tutorials in Mathematics. *In*: P. Rowlett (ed.), *Media Enhanced Teaching and Learning: case studies and evidence of effective use*, pp. 41-44. MSOR Network.
Available via: www.mathcentre.ac.uk/resources/uploaded/METALbooklet.pdf

The website is available via: nestor.coventry.ac.uk/mathsvideos

Appendix A – Timetable of funding

Title	Main focus	Time period during which allocation made	Amount allocated
First call for funding (HE Curriculum Innovation open call).	General call against the National HE STEM Programme strategic aims.	April-May 2010.	£24,000.
Second call for funding (Transfer of proven innovative practice & HE Curriculum Innovation open call).	To encourage transfer or further uptake of already established proven innovative practice.	October-November 2010.	£15,300.
Third call for funding (Summit outcomes & HE Curriculum Innovation open call).	Work briefs based on recommendations from the HE Mathematics Curriculum Summit.	March-May 2011.	£181,800.
Developing Graduate Skills Uptake Programme.	Projects based on ideas from the booklet 'Developing Graduate Skills in HE Mathematics Programmes'.	March-May 2011.	£3,000.
Maths Arcade Uptake Programme.	To set up new Maths Arcades.	October 2011.	£11,000.
Working groups.	Small-scale collaborative activity around specific, focused aims.	December 2011 -January 2012.	£3,850.
Coordination projects.	Projects to coordinate outputs from a group of projects and produce a useful combined output.	December 2011 -January 2012.	£4,500.
Miscellaneous HE Curriculum Innovation.	Small-scale commissioned work throughout as opportunities arose.	April 2010 -January 2012.	£13,900.

Appendix B – People involved with these projects listed by HEI

A list of people at UK higher education institutions who have completed work on one of the projects in this booklet. Also included, because of the impact that the event had on this work, are those who acted as representatives of their institution at the HE Mathematics Curriculum Summit.

University of Bath	**Emma Cliffe** (Good Practice on Inclusive Curricula, Methods to produce flexible and accessible learning resources, Maths Arcade Uptake, Group Work WG); **Jane White** (Methods to produce flexible and accessible learning resources, Maths Arcade Uptake, Summit rep).
Bath Spa University	**Snezana Lawrence** (History of Maths WG).
University of Birmingham	**Chris Sangwin** (MaPS, Summit rep); **Chris Good** (Being a professional mathematician); **Joe Kyle** (MaPS).
Birmingham City University	**Peter Samuels** (A Pilot for a Shared On-line Statistics Advisory Service, Developing Graduate Skills).
University Centre at Blackburn College	**Alexandra Shukie** (Supporting Undergraduate Engagement & Achievement in STEM Disciplines, METAL); **Melissa Conlon**, **Dave Kiddell** and **Nigel Thomson** (Supporting Undergraduate Engagement & Achievement in STEM Disciplines).
University of Bristol	**Martin Homer**, **Oscar Benjamin**, **Jonathan Lawry** and **Jonathan Rossiter** (Industrial Problem Solving for Higher Education Mathematics).
Brunel University	**Martin Greenhow**, **Kinga Zaczek** and **Abdulrahman Kamavi** (Development and integration of computer-aided assessment of discrete mathematics).
University of Cambridge	**Lynne McClure** (PSUM); **Stephen Siklos** (Summit rep).
Cardiff University	**Robert Wilson** (Summit rep).
University of Chester	**Yubin Yan** (Summit rep).
Coventry University	**Trevor Hawkes** (MaPS, The Internet Librarian and Curator for Mathematics Videos); **Matthew Badger** (MaPS); **Sidney Tyrrell** (Developing Graduate Skills).
De Montfort University	**Michele Wrightham** (A Pilot for a Shared On-line Statistics Advisory Service).
University of Derby	**Paul Dale** (Summit rep).
Durham University	**Adrian Simpson** (MU-MAP).
University of Exeter	**Bob Burn** (MaPS, History of Maths WG); **Robin Williams** (Good Practice on Inclusive Curricula); **Peter Ashwin** (Summit rep).
University of Greenwich	**Noel-Ann Bradshaw** (Building on the Maths Arcade, Maths Arcade Uptake, Maths Graduates: where are they now?, Group Work WG, Work-related Learning WG, History of Maths WG); **Tony Mann** (Being a professional mathematician, Models of industrial placements, Progress Files – Greenwich Implementation, History of Maths WG, Building on the Maths Arcade); **Steve Lakin** (Building on the Maths Arcade, Progress Files – Greenwich Implementation); **Kevin Parrott** (Building on the Maths Arcade, Summit rep); **Mike Sharp** (Building on the Maths Arcade).

University of Hertfordshire	**Stephen Kane** (Summit rep).
Keele University	**David Bedford** (Maths Arcade Uptake).
King's College, London	**Luke Hodgkin** (History of Maths WG).
Kingston University	**Nigel Atkins** (Summit rep).
Lancaster University	**James Groves**, **Gordon Blower**, **Eileen Cunningham**, **Lesley Harper**, **Shamim Khan** and **Hendryk Korzeniowski** (Enhancing the communication and speaking skills of mathematics undergraduates).
University of Leeds	**Kevin Houston** (Teaching students to write mathematics, Developing Graduate Skills); **Margit Messmer** (Summit rep).
University of Leicester	**Jeremy Levesley** (Maths Arcade Uptake, Summit rep/speaker); **Stephen J. Garrett** (MU-MAP); **Valerie Matthews-Lane**, **Clive Rix** and **Richard Mendez** (Developing Graduate Skills).
Liverpool Hope University	**Nick Almond** and **Anesa Hosein** (PSUM).
London Metropolitan University	**Pargat Calay** (Summit rep).
Loughborough University	**Carol Robinson** (Student-centred Approaches Coordination, MU-MAP, Engineering Students Understanding Mathematics); **Tony Croft** (Views of graduates on the HE curriculum, Engineering Students Understanding Mathematics, METAL); **Matthew Inglis** (Views of graduates on the HE curriculum); **Alun Owen** and **Mollie Gilchrist** (A Pilot for a Shared On-line Statistics Advisory Service); **Barbara Jaworski** (Engineering Students Understanding Mathematics); **Janette Matthews** (Views of graduates on the HE curriculum, Engineering Students Understanding Mathematics); **Paul Hernandez-Martinez** (MU-MAP, METAL); **Clare Trott** (Good Practice on Inclusive Curricula); **Ian Jones** (MU-MAP); **Lara Alcock** (MU-MAP); **Stephen Broughton** (MU-MAP); **Steve Kenny** (Summit rep).
London School of Economics and Political Science	**Nicola Martin** (Good Practice on Inclusive Curricula).
University of Manchester	**Sue Pope** (PSUM); **Louise Walker** (Developing Graduate Skills, Maths Arcade Uptake, Summit rep).
Newcastle University	**Shirley Coleman** (Industrial Problems for the HE Curriculum in Statistics); **Bill Foster** (Summit rep).
University of Nottingham	**Joel Feinstein**, **Claire Chambers**, **Sally Hanford**, **Nicki Keating** and **Michèle Clarke** (METAL); **Stephen Hibberd** (Developing Graduate Skills); **Sally Barton** (Maths Arcade Uptake); **Emma Rowlett** (Good Practice on Inclusive Curricula).
Nottingham Trent University	**James Hind** (Supporting progression in mathematics education, Summit rep); **Timothy J. Hetherington** (MU-MAP); **Rob Kearsley Bullen** (METAL).
Open University	**Gareth Williams** (Developing Graduate Skills); **Martyn Cooper** and **Jonathan Fine** (Good Practice on Inclusive Curricula).
University of Oxford	**Robin Wilson** (History of Maths WG); **Alastair Irving** (Good Practice on Inclusive Curricula).
Oxford Brookes University	**Mary McAlinden** (Developing Graduate Skills, Summit rep).

Plymouth University	**Neville Davies** and **John Marriott** (A Statistical Awareness Curriculum for STEM Employees, Industrial Problems for the HE Curriculum in Statistics); **David Graham** (Developing Graduate Skills, MU-MAP, Summit rep); **Paul Hewson** (MU-MAP); **Annette Millar** (Developing Graduate Skills).
University of Portsmouth	**Andrew Osbaldestin** (Summit rep).
Queen Mary, University of London	**Franco Vivaldi** (Teaching students to write mathematics).
University of Reading	**Nick Biggs** (Summit rep).
University of Salford	**Edmund Chadwick** (Assessing student teams developing mathematical models in business and industrial mathematics, Work-related Learning WG, Maths Arcade Uptake, Developing Graduate Skills, MU-MAP, Summit rep); **Kevin Sandiford** and **David Percy** (Assessing student teams developing mathematical models in business and industrial mathematics); **David McNulty** (Work-related Learning WG).
Sheffield Hallam University	**Jeff Waldock** (Developing Graduate Skills, Employer Engagement Coordination Project, Work-related Learning WG); **Claire Cornock** and **Erik Baxter** (Maths Arcade Uptake); **Mike Robinson** (Teaching students to write mathematics); **Neil Challis** (Summit rep/speaker).
University of St Andrews	**Colva M. Roney-Dougal** (History of Maths WG).
University of Strathclyde	**Steven D. Webb** (Good Practice on Inclusive Curricula).
University Campus Suffolk	**David Bowers** (Developing Graduate Skills).
University of Sunderland	**Bernadette Leckenby** (A Pilot for a Shared On-line Statistics Advisory Service).
Swansea University	**Andrew Neate** and **Kristian Evans** (Mathematical Presentation and Communication Skills within the Core Curriculum).
University of Central Lancashire	**Vicki Tariq** (Developing Graduate Skills); **Terrance Haydock** (Work-related Learning WG).
University of East Anglia	**Paola Iannone** and **Oana Radu** (MU-MAP); **Peter Crompton** (Summit rep).
University of Ulster	**Mark McCartney** (History of Maths WG, METAL).
University of the West of England	**Kevin Golden** and **Guy Roberts** (Developing Graduate Skills); **Alison Hooper** (Summit rep).
University of Wolverhampton	**David Wilkinson** (Summit rep).

Appendix C – List of events associated with this project

'Using IT when teaching mathematics classes', workshop, 19th November 2010, University of Nottingham.

'Embedding Graduate Skills in Your Mathematical Sciences Programme', workshop, 24th November 2010, Sheffield Hallam University.

'HE Mathematics Curriculum Summit', 12th January 2011, University of Birmingham.

'Maths, Stats and OR Accessibility Workshop', 21st February 2011, University of Bath.

'Findings from the HE Mathematics Curriculum Summit and details of a £150,000 funding call in Mathematical Sciences HE Curriculum Innovation' (these meetings disseminated the Summit report). This meeting took place at:

- Cardiff University, 31st March 2011 (jointly with the National HE STEM Programme Wales Spoke);
- University of Greenwich, 4th April 2011;
- University of York, 18th April 2011 (jointly with the National HE STEM Programme North East Spoke);
- University of Birmingham, 19th April 2011 (jointly with the National HE STEM Programme Midlands and East Anglia Spoke);
- Manchester Metropolitan University, 5th May 2011 (jointly with the National HE STEM Programme North West Spoke);
- University of Bath, 10th May 2011 (jointly with the National HE STEM Programme South West Spoke).

'Maths Strand of the National HE STEM Programme' (presentation by Michael Grove, Moire Petrie, Peter Rowlett, Hazel Kendrick and Makhan Singh), Heads of Departments of Mathematical Sciences (HoDoMS) Conference, 7th April 2011, University of Birmingham.

'Innovation in mathematics HE teaching & learning' (presentation by Peter Rowlett), Young Researchers in Mathematics Conference 2011, 14th April 2011, University of Warwick.

'Technology in mathematics HE teaching & learning' (presentation by Peter Rowlett), Young Researchers in Mathematics Conference 2011, 15th April 2011, University of Warwick.

'Developing Graduate Skills in HE Mathematics Programmes' (these workshops disseminated the booklet of the same title). This workshop took place at:

- University of York, 18th April 2011 (jointly with the National HE STEM Programme North East Spoke);
- Manchester Metropolitan University, 5th May 2011 (jointly with the National HE STEM Programme North West Spoke);
- University of Bath, 10th May 2011 (jointly with the National HE STEM Programme South West Spoke);
- University of Greenwich, 17th May 2011;
- University of Birmingham, 19th May 2011 (jointly with the National HE STEM Programme Midlands and East Anglia Spoke).

'Teaching students to write mathematics', workshop, 12th May 2011, University of Leeds.

‘Media Enhanced Teaching and Learning (METAL) First Workshop’, 27th May 2011, University of Nottingham.

‘Media Enhanced Teaching and Learning (METAL) Second Workshop’, 22nd June 2011, University of Nottingham.

‘Developing mathematical thinking through problems, puzzles and games’, workshop, 1st July 2011, University of Greenwich.

‘Ideas Exchange: HE Mathematics Curriculum Innovation’, 9th-10th July 2011, University of Birmingham. (Workshop report published in *MSOR Connections*, 11(3), pp. 54-55.)

‘Encouraging innovation in HE mathematics teaching and learning’ (presentation by Peter Rowlett), 14th IMA Early Career Mathematicians Conference, 16th July 2011, University of Leicester.

‘CETL-MSOR Conference 2011’, 5th-6th September 2011, Coventry University (no funding was provided from this project but this MSOR Network/sigma conference provided a major dissemination focus for projects in this booklet).

‘Project evaluation and dissemination’, workshop, 26th October 2011, University of Birmingham.

‘MU-MAP – Mapping University Mathematics Assessment Practices Workshop’, 17th November 2011, Loughborough University.

‘Media Enhanced Teaching and Learning (METAL) Third Workshop’, 11th January 2012, University of Nottingham.

‘Problem-Solving in Undergraduate Mathematics’ (presentation by Sue Pope, Matthew Badger and Peter Rowlett), British Society for Research into Learning Mathematics Conference, 3 March 2012, University of Manchester.

‘Work-related Learning Working Group meeting’, 7th March 2012, University of Salford.

‘Maths Arcade Training Day’, 7th March 2012, University of Salford.

‘Group Work Working Group meeting’, 13th March, University of Bath.

‘Maths Arcade Training Day’, 16th March 2012, Sheffield Hallam University.

‘Mathematics lecturers’ views of e-assessment’ (seminar by Peter Rowlett), 21st March 2012, Newcastle University.

‘Student input into employability’ (seminar by Barrie Cooper), 23rd March 2012, Sheffield Hallam University.

‘Outputs and Outcomes from the Maths Strand Team of the National HE STEM Programme’ (presentation by Makhan Singh, Hazel Lewis, Peter Rowlett and Dagmar Waller), Heads of Departments of Mathematical Sciences (HoDoMS) Conference, 13th April 2012, University of Birmingham.

‘Using social media to engage students in mathematical sciences’, workshop, 16th April 2012, University of Birmingham.

‘How we assess mathematics students: a survey and case studies’ (MU-MAP workshop), British Mathematical Colloquium, 16th-19th April 2012, University of Kent.

‘Media Enhanced Teaching and Learning (METAL) Dissemination Meeting’, workshop, 24th April 2012, University of Nottingham.

‘Graduate skills and interactive lectures’ (seminar by Peter Rowlett), 27th April 2012, Queen Mary, University of London.

‘Graduate Skills Development’ (seminar by Peter Rowlett), 30th April 2012, University of Hertfordshire.

‘Maths Arcade Evaluation Workshop’, 30th April 2012, University of Leicester.

‘Group Work Working Group meeting’, 8th May 2012, University of Birmingham.

‘Recording lectures and learning from recordings’ (seminar by Peter Rowlett), 9th May 2012, University of Greenwich.

‘Work on HE Curriculum Innovation in Mathematical Sciences’, presentation by Peter Rowlett at the workshop Maths Strand Outputs in the National HE STEM Programme. This took place four times:

- 10th May 2012, Manchester Metropolitan University;
- 17th May 2012, London Metropolitan University;
- 25th May 2012, University of Birmingham;
- 30th May 2012, Cardiff University.

‘Placements for Mathematics undergraduates’, workshop, 14th May 2012, University of Greenwich.

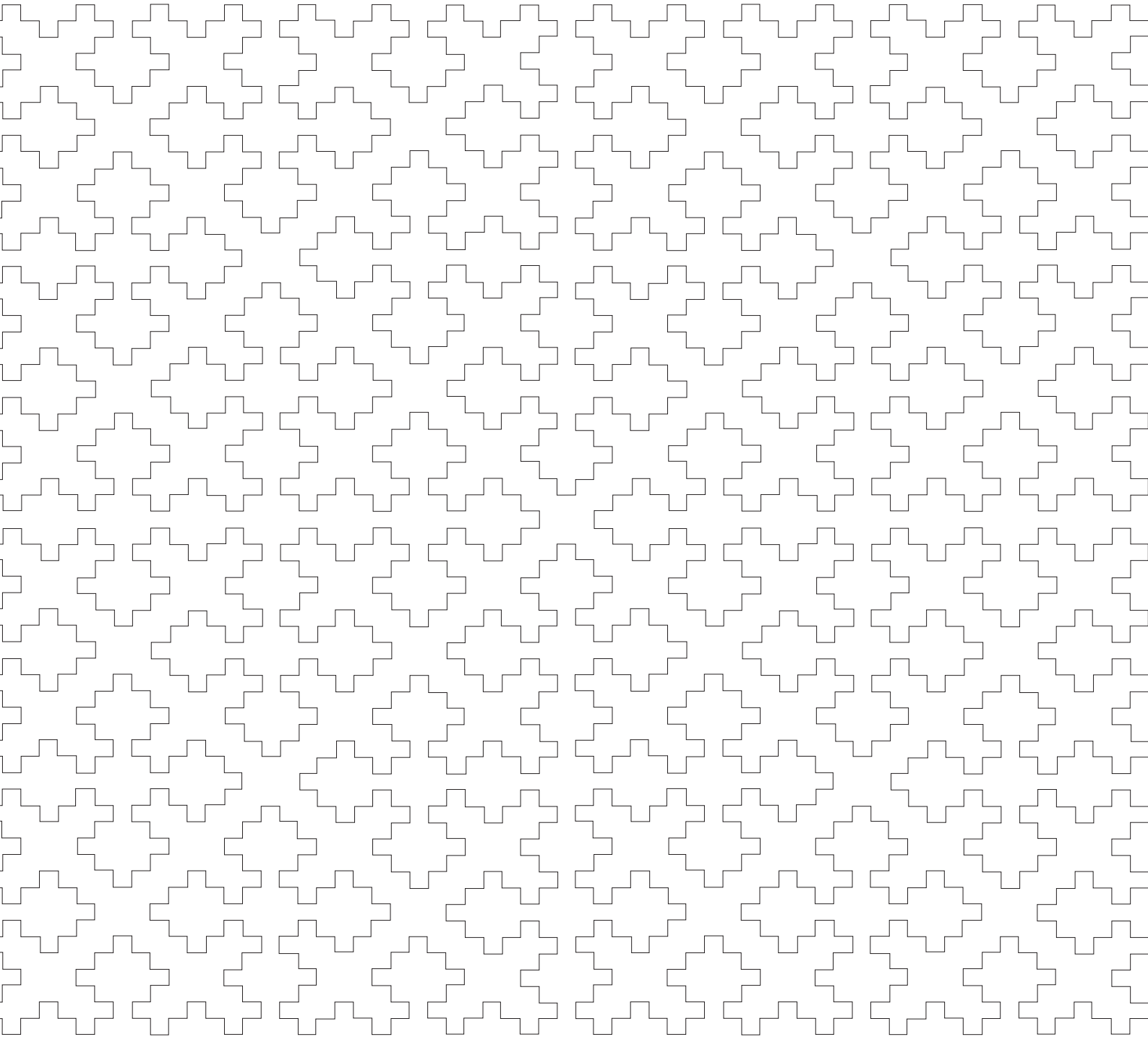
‘Being a professional mathematician’, workshop, 15th May 2012, University of Greenwich.

‘British Society for Research into Learning Mathematics Conference’, 9th June 2012, University of Sussex (the project ‘Views of Graduates on HE Curriculum’ and several of the ‘MU-MAP’ mini-projects presented at this meeting).

‘Making lectures more interactive’ (seminar by Peter Rowlett), 6th July 2012, Oxford Brookes University.

‘CETL-MSOR Conference 2012’, 12th-13th July 2012, University of Sheffield (funding was provided to this conference which provided a major dissemination focus for projects in this booklet).

‘Ideas Exchange 2012: HE Mathematics Curriculum’, 14th-15th July 2012, University of Sheffield.



Appendix D – List of publications associated with this project

Major publications

Badger, M.S., Sangwin, C.J., Hawkes, T.O., 2012. *Teaching Problem-solving in Undergraduate Mathematics*. Coventry University. Available via: www.mathcentre.ac.uk/problemsolving

Bradshaw, N. and Rowlett (eds.), 2012. *Maths Arcade: stretching and supporting mathematical thinking*, MSOR Network.
Available via: www.mathcentre.ac.uk/resources/uploaded/MathsArcade.pdf

Cliffe, E. and Rowlett, P. (eds.), 2012. *Good Practice on Inclusive Curricula in the Mathematical Sciences*. MSOR Network.
Available via: www.mathcentre.ac.uk/resources/uploaded/InclusiveCurricula.pdf

Iannone, P. and Simpson, A. (eds.), 2012. *Mapping University Mathematics Assessment Practices*. University of East Anglia. Available via: www.uea.ac.uk/edu/mumap

Inglis, M., Croft, T. and Matthews, J., 2012. *Graduates' Views on the Undergraduate Mathematics Curriculum*. MSOR Network.
Available via: www.mathcentre.ac.uk/resources/uploaded/GradViews.pdf

Mann, T. and Good, C., 2012. *Being a Professional Mathematician*. MSOR Network.
Available via: www.mathcentre.ac.uk/resources/uploaded/BeingAProMathematician.pdf

McCartney, M. (ed.) (2012). *History of Mathematics in the Higher Education Curriculum*. MSOR Network. Available via: www.mathcentre.ac.uk/resources/uploaded/HistoryofMaths.pdf

Owen, A., Samuels, P., Wrightham, M., Leckenby, B. and Gilchrist, M., 2011. *A Pilot for a Shared Online Statistics Advisory Service*. MSOR Network.
Available via: www.mathcentre.ac.uk/resources/uploaded/SharedSAS.pdf

Robinson, C. (ed.), 2012. *Student-centred Approaches in Mathematics*. MSOR Network.
Available via: www.mathcentre.ac.uk/resources/uploaded/Studentcentred.pdf

Rowlett, P. (ed.), 2011. *HE Mathematics Curriculum Summit*. MSOR Network.
Available via: www.mathcentre.ac.uk/resources/uploaded/SummitReport.pdf

Rowlett, P. (ed.), 2011. *MSOR Connections*, 11(3).
Available via: www.mathcentre.ac.uk/resources/uploaded/MSORConnections113.pdf

Rowlett, P. (ed.), 2012. *Further Work Developing Graduate Skills in HE Mathematics Programmes*. MSOR Network.
Available via: www.mathcentre.ac.uk/resources/uploaded/FurtherGradSkills.pdf

Rowlett, P. (ed.), 2012. *Media Enhanced Teaching and Learning: case studies and evidence of effective use*. MSOR Network.
Available via: www.mathcentre.ac.uk/resources/uploaded/METALbooklet.pdf

Waldock, J. (ed.), 2011. *Developing Graduate Skills in HE Mathematics Programmes - Case Studies of Successful Practice*. MSOR Network.
Available via: www.mathcentre.ac.uk/resources/uploaded/GradSkills.pdf

Waldock, J., and Rowlett, P. (eds.), 2012. *Employer Engagement in Undergraduate Mathematics*. MSOR Network.
Available via: www.mathcentre.ac.uk/resources/uploaded/EmployerEngagement.pdf

Other publications and reports

Work under this project was reported in:

- *MSOR Connections* (10(3), p. 51; 11(1), p. 51; 11(2), p. 47; 12(1), p. 48; 12(2), forthcoming)
- *HESTEMnews* (Autumn 2010, p. 8; Winter 2012, p. 31; Spring/Summer 2012, p. 7; Spring/Summer 2012, p. 9; Spring/Summer 2012, p. 11; Summer 2012, p. 14)
- *Mathematics Today* (47(2), p. 80; 47(2), p. 81; 47(4), p. 177; 48(2), p. 68; 48(3), p. 118; one more forthcoming)
- *LMS Newsletter* (401, p. 9; 402, p. 16; 414, pp. 15-16; 415, pp. 14-15; one more forthcoming)
- *RSS News* (39(2), p. 8; 40(4), p. 8)
- *Inside O.R.* (483, p. 9; one more forthcoming).
- Rowlett, P., 2011. The Mathematical Sciences HE Curriculum Innovation Project. *Peer Assisted Learning: in and beyond the classroom Briefing Document 2*, p. 6. Bournemouth University.
- Waldock, J. and Rowlett, P., 2011. Embedding graduate skills in mathematics programmes. *AGCAS Phoenix*, 132, p. 28.

This booklet presents summaries of the work completed under the Mathematical Sciences HE Curriculum Innovation Project from 2010-12 and provides links to access the resources produced.

Work is presented on: developing graduate skills from within the curriculum and by engaging with employers; making available industrial problems in maths and stats; teaching and assessing problem solving; mathematical thinking; student support; inclusive curricula; non-traditional methods of assessment; use of audio-visual media in teaching and learning.

The Mathematical Sciences HE Curriculum Innovation Project was operated by the Maths, Stats and OR (MSOR) Network, working with the Institute of Mathematics and its Applications (IMA) as part of the Mathematical Sciences Strand of the National HE STEM Programme.

www.mathstore.ac.uk/hestem

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Download a copy of this booklet and others associated with this work by visiting **www.mathcentre.ac.uk/staff/topics** and looking under “HE STEM Projects”.