ADVISORY COMMITTEE ON MATHEMATICS EDUCATION ANNUAL CONFERENCE 2008

Mathematics within STEM- a policy perspective

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1 Introduction

On 27 February 2008, the Advisory Committee on Mathematics Education (ACME) held its annual conference, with the aim of discussing the place of mathematics within the Science, Technology, Engineering and Mathematics (STEM) agenda.

The conference was chaired by Professor Adrian Smith, FRS. Speakers included representatives from the Royal Society, the Department for Children, Schools and Families (DCSF)¹, the Mathematical Association (MA), the Secondary National Strategy (SNS), the Innovation, Universities, Science and Skills Committee and the British National Space Centre, as well as practitioners from schools and colleges. Delegates were able to pose questions to the speakers and to discuss their views in the afternoon workshop sessions.

2 Summary of ACME’s key messages from the conference

- Mathematics has a key role to play in the STEM agenda, since it underpins the disciplines of science, engineering and technology, but it is also an important subject in its own right and must maintain its identity.

- It is vital that information about the opportunities created by STEM, resources for enrichment and enhancement (E&E), and the available funding gets to the people who need it. The planned science, mathematics and engineering E&E directories² should help to achieve this if communication channels are improved.

- The E&E directories should be in hard copy and online, thus allowing for regular updates, and should have links between the resources and the National Curriculum, across all subjects.

- Schools need to be aware of the benefits of E&E so that they see the benefit of taking a step away from the curriculum. This is difficult because the benefits are not easily measured and it is difficult to set targets for how much learners are enriched.

¹ On 28 June 2007, the DfES was split into three departments: DCSF – Department for Children, Schools and Families, DIUS – Department for Innovation, Universities and Skills, and DBERR – Departments for Business, Enterprise and Regulatory Reform.

² The Department for Children, Schools and Families (DCSF) has launched a three-year programme to develop directories of science, mathematics and engineering E&E activities (activities that extend students learning beyond their normal classroom experience) ACME is the lead organisation for the mathematics directory. The goal is to improve co-ordination of ‘the delivery of opportunities for curriculum enhancement and enrichment’ and ‘to increase the number of schools, colleges and students which benefit from such activities and support.’ To learn more about E & E and the directories : www.acme-uk.org/page.asp?id=47
• Teachers need time to prepare and gain ownership of STEM enrichment activities and need Continuing Professional Development (CPD) in order to assess how much time is needed to plan and deliver these activities.

• More thought needs to be given to the mathematics content of the specialised diplomas. It is felt that it is currently insufficient to equip students going on to undergraduate studies in STEM subjects.

• CPD is needed to support primary teachers in improving and deepening their subject and pedagogical knowledge in order to give them confidence to move away from the constraints of the current assessment system and to engage and motivate children.

• Learning should not be compartmentalised, so cross-curricular learning in conjunction with the other STEM subjects is very important, but quality CPD is needed in order for this to become embedded practice, with sufficient time for teachers to engage in this.

• It is important that information about careers and further education, particularly in relation to the STEM disciplines, be available to teachers and students in secondary schools and colleges so that they can see how mathematics underpins these and therefore the opportunities that can be presented to learners.

• The new Secondary Curriculum has allowed conditions for a new way of thinking about cross-curricular issues, making learning more exciting, engaging and relevant. STEM is a vehicle for this to happen in a key strategic area, though it is important to ensure that individual subject identity is maintained.

• It is important that the new science and mathematics curricula marry up to ensure coherence across the STEM subjects.

• STEM may make mathematics teachers feel inadequate because they don’t have the requisite knowledge about science. This may mean that mathematics departments will have to rely on colleagues in the STEM departments and work more closely together.

• It is unclear whether the STEM agenda applies to primary education and this needs further exploration.

• Mathematics is relevant to subjects other than science, technology and engineering, for example social studies, and there is research evidence to show that mathematical skills can enhance progress in other subjects.

3 http://www.acme-uk.org/news.asp?id=91
There is a national drive to equip classrooms with interactive whiteboards and an internet connection, which will be relevant to the needs of the STEM subjects, but teachers need to be trained to use this equipment effectively for this to have an impact on educational outcomes.

3 Speakers

3.1 Lord Rees of Ludlow, President, The Royal Society

Lord Rees opened his address with three fundamental ‘truths’ about mathematics:

- Mathematics is crucial to scientists because it is the language of science.
- Mathematics underpins learning in all phases of school, college and higher education.
- Mathematics is important not only for those who are going to be specialists in mathematics and engineering, but for the majority of the population in order to meet the everyday challenges of life, work and citizenship.

He then outlined the ways in which the Royal Society had become more engaged in school level education and in the STEM agenda in recent years. He said that the Society was proud to be the catalyst for change in mathematics education through hosting ACME and through its relationships with other organisations, especially the National Centre for Excellence in the Teaching Mathematics (NCETM), The Council for the Mathematical Sciences, the Royal Academy of Engineering and the Science Community Representing Education (SCORE). Lord Rees congratulated ACME for the work it had done in recent years to turn around mathematics education and said that Adrian Smith’s report ‘Making Mathematics Count’ had been a very important impetus for change in mathematics education.

To learn more about mathematics and the Royal Society: www.royalsociety.org

3.2 Professor Adrian Smith FRS, Chair, ACME

Professor Smith announced that ACME’s funding by the DCSF and the Gatsby Charitable Foundation would continue for a further three years and thanked all those concerned with ACME funding. He noted the high profile of STEM in the Government’s current policy and the welcomed presence of Helen Williams, Director of Curriculum and Student Well-Being, who was charged with looking at mathematics policy within the STEM agenda. This, he said, was

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very high profile within DCSF and DIUS, and a high level strategy group is looking at the landscape of STEM. He said that it was very important for the mathematics community to think carefully about its positioning within STEM and consider how it should impact on the broad landscape of activity.

3.3 Helen Williams, Director of Curriculum and Student Well-Being, DCSF

Ms Williams informed the conference of the progress that had been made since ‘the Smith Report’ in 2004. She addressed each of the three key findings of the Report in turn.

1. The shortage of specialist mathematics teachers: The DCSF, she said, was working very closely with the Training and Development Agency for Schools (TDA) which had introduced measures to stimulate the recruitment of mathematics specialist teachers into both secondary and further education. Progress was being made, for example 2500 mathematicians were being recruited into teacher training every year, compared with less than 1500 ten years ago, but the DCSF still had a long way to go to meet the target of 95% of mathematics lessons in secondary schools being delivered by mathematics specialists by 2014.

2. The lack of an infrastructure to support mathematics teaching, particularly in terms of CPD: The DCSF had tackled this issue, said Ms Williams, by establishing the NCETM, which was playing an important leadership role, both nationally and regionally, to ensure that the supply of CPD meets the needs of mathematics teachers and that teachers are encouraged to take up CPD opportunities. The DCSF was also continuing to support mathematics teachers in both primary and secondary schools with the Primary National Strategy and the Secondary National Strategy, as well as supporting the NCETM in improving the teaching and learning of mathematics post-16.

3. The curriculum and assessment framework was not sufficiently flexible to meet the needs of all learners: Ms Williams summarised the DCSF’s progress:

- It had changed the structure of GCSE Mathematics to give all students the opportunity to gain a grade C.
- The new Key Stage 3 programme of study in mathematics (for first teaching in 2008) would place more emphasis on the use and application of mathematics, with similar changes being made to the Key Stage 4 programme of study from 2010.
The emphasis on Functional Mathematics in the new secondary programmes of study would prepare students for the new assessments in functional skills. In future, learners must achieve Level 2 in Functional Mathematics in order to be awarded a higher grade A* to C pass in GCSE Mathematics.

It had introduced the second mathematics GCSE, for first teaching from 2010. Most students will continue to do the first mathematics GCSE, for which in future they will also need to be assessed in functional skills. The DCSF expects that 50% of the cohort will also take the second mathematics GCSE.

The Qualifications and Curriculum Authority (QCA) had been tasked with ensuring that the developments in GCSE and functional skills and the perspective changes in AS and A Level would together offer coherent, clear pathways for students in relation to mathematics. This work, she said, needed to take account of the new specialised diplomas being phased in from September 2008, which would support the aim of increasing the numbers of young people studying mathematics.

Underpinning these developments, said Ms Williams, was a more strategic leadership, which had entailed the appointment of Celia Hoyles as Chief Advisor for Mathematics (2004–2007), the department’s support of ACME in terms of funding and better organisation within the department.

Ms Williams then moved onto the subject of mathematics in primary schools, where the foundations of successful learning in mathematics are laid. The publication of Sir Peter Williams’ interim report on mathematics teaching in primary schools was imminent. His remit was to look at pedagogy and how best to provide for children across the full ability range, to decide what conceptual and subject knowledge should be required of primary teachers, and to advise on the effective design of the primary mathematics curriculum, the last of which would feed into Sir Jim Rose’s review of the whole primary curriculum.

Ms Williams concluded that there was much to be optimistic about, such as a steady, if incremental, rise in the numbers of students reaching the expected National Curriculum levels of attainment at age 11, 14 and 16, and a very encouraging recovery in the numbers of those doing A Level Mathematics since 2004, particularly those doing Further Mathematics A Level. The DCSF was also very encouraged by the progress of the NCETM under the direction of Celia Hoyles in promoting CPD for mathematics teachers. However, the department recognised the challenge of ensuring the effective implementation of the various reforms in the curriculum and assessment framework and the qualifications framework so as to minimise

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5 ‘Functional skills’ qualifications are being introduced for 2010 in mathematics, English and information and communication technology (ICT) for learners 14 and above.

6 Subsequently, the DCSF indicated that this value was not a fixed percentage.
the impact on the workloads of teachers and schools. The DCSF also recognised that ensuring an adequate national supply of qualified mathematics teachers represented a continuing challenge, notwithstanding the TDA’s relative success.

Ms Williams said that the DCSF set great store by ACME’s independent advice and would continue to support its work by ensuring that the Chair of ACME had regular access to ministers. She also said that that there would be a clear consultation process between ACME and the DCSF before key decisions were taken.

3.3.1 Question and answer session

Q. Regarding 50% of the cohort taking the second GCSE, in what sense did Ms Williams mean the word ‘expect’?

A. Ms Williams replied that it would not be compulsory but that the DCSF hoped to see 50% of the cohort taking the second mathematics GCSE, which was designed to provide additional challenge for those students who were motivated to deepen their work in mathematics. The QCA’s remit was to design a qualification which would be accessible to and attractive to at least 50% of the cohort. Piloting was underway, but decisions were still to be taken about specification. She added that the second mathematics GCSE would cover exactly the same ground as the first mathematics GCSE, with the difference being that the second mathematics GCSE would have greater emphasis on the application of mathematical processes. Students could get this second GCSE without any extra teaching, which should be attractive to schools, because students could get ‘two GCSEs for the price of one’.

Q. Would a student need both mathematics GCSEs in order to study A Level Mathematics?

A. Ms Williams replied that the intention was that the first GCSE, ‘the gatekeeper GCSE’, would still be suitable for progression to A Level Mathematics. It is very important to avoid posing another hurdle to progression to A Level Mathematics.

Q. Does the DCSF have any plans for motivating unmotivated students?

A. The DCSF, she said, was working with ACME to create directories of the enrichment and enhancement resources that are available to schools. It was proposing to map all these resources to the National Curriculum. She also mentioned work that the DCSF was doing with

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7 See previous footnote.
the Bowland Trust\textsuperscript{8} on the development of Key Stage 3 resource materials that help students to apply their mathematics to interesting, real-life problems and issues.

**Comment from Celia Hoyles:** Ms Hoyles reiterated the point that Ms Williams made about the Bowland Initiative. The initiative, she said, was recognition of the importance of trying to have a different view of mathematics and involved some fascinating case studies of how mathematics is used, as well as a whole package of professional development. She said that it would be very motivating for learners, which was why the NCETM was supporting Bowland and informing teachers about it.

**Q.** Is there still a need for at least a part-time chief advisor role to continue the important work that Celia Hoyles carried out?

**A.** The DCSF had decided not to appoint a successor for two reasons: Firstly, that Celia Hoyles was appointed to work on the immediate follow up to Professor Smith’s report, which was largely complete at the end of her three-year tenure. Secondly, that the DCSF had other sources of advice on mathematics, particularly because of the department’s relationship with ACME, as well as professional advice from the QCA. She mentioned that the DCSF still had the benefit of Professor Hoyles’ advice in her capacity as director of the NCETM. The situation would be kept under review.

**Q.** Improvements in staffing may have been happening, but they are not uniform across the country. Staffing issues affect teaching because it is difficult to make progress on all of the changes to the programmes of study when a lot of time is spent trying to plug staffing gaps.

**A.** Ms Williams mentioned two new schemes: Firstly, a transition to teaching scheme, which would encourage mature people who are qualified in science and mathematics and who have careers in industry, to switch to teaching. Secondly, the TDA was piloting CPD courses that give accredited training to people who have been teaching mathematics but without a specialist qualification, in order to deepen their subject knowledge and their subject-specific pedagogy.

**Q.** With regard to the retention of mathematics teachers, many of them progress to senior management and therefore do not have the time to do any classroom teaching. What

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\textsuperscript{8} The Bowland maths case studies for Key stage 3 scheme is a program being developed by the Bowland Trust with support from the DCSF. It ‘will consist of an initial 23 case study problems each of which pupils would need to address through open questions; each problem will be able to be explored at various depths’. For more information: [www.bowlandmaths.org.uk/](http://www.bowlandmaths.org.uk/)


measures are in place to help head teachers by giving them less paperwork in order to enable them to return to the classroom and develop the curriculum using their expertise?

A. Ms Williams said that it was the responsibility of individual head teachers to manage their schools effectively by appointing a good head of mathematics and by ensuring that the paperwork is not the responsibility of the people with specialist mathematics qualifications.

Q. Would the funding cap allow students to take AS or A Level Mathematics alongside Level 3 diplomas?

A. The line that the DCSF was taking was that students could take A Level Mathematics alongside the diploma or, more likely, as part of the diploma. However, the Learning and Skills Council (LSC) rules may steer people towards taking their A Level Mathematics within the diploma.

3.4 Rob Eastaway, President, Mathematical Association (MA)

Mr Eastaway applauded projects such as the Bowland Initiative that would help to demonstrate the importance of mathematics in science, technology and engineering. It is vital for schools, he said, to see that mathematics has practical applications, and it is equally important for aspiring scientists and engineers to realise that they need mathematics in order to progress very far. However, Mr Eastaway cautioned that the mathematics community should not see STEM as the solution to all of its problems, for four reasons.

1) Not all areas of mathematics have obvious applications: some topics simply teach students how to think mathematically, a profoundly important skill for industry. It is important, he said, to make connections between mathematics and the real world, but educators should be cautious about how much they stress the application of mathematics. He said that teachers could play a key part in making mathematics enjoyable: if students are enjoying mathematics, somehow the need to stress the application goes away.

2) Educators should enrich but not dilute. Schools face the dilemma of whether or not to give students an enrichment lecture if it is not directly relevant to them passing the exam at the end of the course. He said that it is vital that schools buy into STEM enrichment: if mathematics teachers are not convinced that enrichment activities will help them to achieve their targets they will not get involved. Many of the benefits of enrichment, he said, are soft and difficult to measure, whereas exam results are very easy to measure. He said that through enrichment from the UK Mathematics Trust, Nrich, Access to Further
Mathematics, The Royal Institution of Great Britain and Maths Inspiration, for example, students can see the big picture of why mathematics is so important, which would indirectly lead to better results. The STEM network and the directories of E&E activities would provide more opportunities for schools to get involved.

3) How many students can be reached with enrichment? Mr Eastaway took Year 10 as an example and estimated that out of 750 000 students, at most, 20 000 students had listened to a mathematics speaker, either in school or out of school. He said that the best solution is for enrichment to happen in the classroom, in which case teachers need to be given the opportunity to step back from the curriculum occasionally to do that enrichment.

4) The position of mathematics in the acronym STEM implies to some people that mathematics comes last, when, in fact, science and engineering depend far more on mathematics than mathematics depends on them. He said that perhaps the mathematics community needed to think about changing the priorities in STEM.

3.4.1 Question and answer session

Q. How would enrichment fit into the current situation with the Government’s obsession with results and targets? How would teachers be persuaded to move away from those?

A. Mr Eastaway said that a fundamental law of human nature is that people respond to targets, so it may be necessary to set targets for how much you enrich people. He said that the next step is for teachers to see what enrichment is and to know what opportunities there are and how to exploit them. He pointed out the paradox that the more enrichment is formalised, the more it loses its inherent natural improvisation. If it became part of the system it would lose some of its enrichment value. The key is to find a balance.

Sue Pope, QCA: Ms Pope commented that with the changes to the curriculum and its emphasis on mathematical processes, enrichment was not outside the curriculum, it was very much part of the curriculum.

Q. Is there a gap in professional development for mathematics teachers in relation to enhancement and enrichment?

A. Mr Eastaway replied that there are a number of ways to approach the need for training in E&E: some training in enrichment was already happening, for example through the UK Mathematics Trust, the Mathematical Association, the Further Mathematics Network (FMN), Nrich and the Association of Teachers of Mathematics; the NCETM network is important for
teachers to discuss and share ideas; there are events and conferences that bring teachers
together to discuss mathematics in the wider picture and to see how other schools are
applying it; schools could invite input from people from industry, who can talk about
mathematics articulately and bring it to life.

4 Examples of good practice in combining mathematics with other subject areas

4.1 Natalie Wallace, Class Teacher, Westfields Junior School, Hampshire

Ms Wallace shared her experience of a project which involved her students, carrying out a
data handling task over the course of a week, finally presenting their findings using
PowerPoint. The project covered objectives from mathematics, ICT and literacy. Ms Wallace
felt that there was a real buzz in the classroom and a sense of collaborative learning. She felt
that the task had given the children a clear understanding of the whole data handling process,
giving them real-life experience to draw on.

For more information, click here.

4.2 Helen Humble, Head of Mathematics, and Judith Weedon, Deputy Head of
Mathematics, Amery Hill School, Hampshire

Ms Humble and Ms Weedon had developed resources for a Year 8 project involving maths
and geography. The quantitative nature of the analysis allowed the students to appreciate the
qualitative aspects of the geography. Key issues included: timing the project so that the
geography linked in with the mathematics; a context and a task that allowed the mathematics
department to address the appropriate learning objectives from the scheme of work, both
consolidating their existing skills and developing new skills; the task had to use real and non-
trivial mathematics; it was not to be a research project so all of the necessary data was
provided.

For more information, click here.

4.3 David Mountney, Principal, Thorns Community College, West Midlands

Mr Mountney said that his college was taking the idea of cross-curricular learning one step
further by trying to create an atmosphere in which mathematics and other subjects could work
together creatively. The college, he said, had moved towards having faculties rather than
subject departments. They realised that the learning experience changes drastically in the
transition from primary to secondary, in that students move from all topics being taught by one teacher to each subject or topic being taught by a different teacher. This encourages students to compartmentalise their learning and makes it difficult for students to apply what they have learnt in one subject to other subjects.

The college had adopted a model whereby most of the time each faculty focuses on the National Curriculum and assesses learning but during ‘creativity weeks’ the faculties must find ways of working together in order to link shared skills, the idea being that learning travels beyond a single classroom.

For more information, click here.

5 A policy perspective

5.1 Teresa Smart, Programme Director for Mathematics, Secondary National Strategy

Ms Smart said that the challenge for her team was to keep the focus on the ‘M in STEM’. She said that the UK needs to create a body of people who are well qualified in science, engineering, technology and mathematics, but firstly there is a need for a supply of mathematically competent people, as a sound basis for developing STEM. She said that keeping the focus on mathematics is vital, not at the expense of the other subjects, but alongside them.

There are, said Ms Smart, many opportunities offered by STEM, for example through the new secondary curriculum under a new framework. She applauded educators who were teaching mathematics as a creative activity rather than treating mathematics as a set of exercises to pass an exam. She said that the introduction of two mathematics GCSEs was an opportunity to do this, stating that in her opinion 80% of students should have access to the second GCSE, as well as functional mathematics. This would help to develop the idea of mathematics as a creative discipline, as would the opportunities being created by the Bowland Trust.

Ms Smart closed with the statement that if STEM is enriched by strengthening each of the individual subjects, the sum of STEM will be far greater than its individual parts.

5.2 Steve Ive, Acting Head Teacher, Kennington Church of England Junior School

Mr Ive had recently completed an MA Educational Studies dissertation that focused on the factors affecting the motivation of students to learn mathematics in Key Stage 2, for which he had used his school as a case study. He found that the majority of the students had formed
clear opinions about mathematics, which they believed were unlikely to change as they moved through school and into adult life. About half of the students held negative or indifferent views about mathematics, citing the following reasons: difficulties in understanding, anxiety caused by pressure to perform, boredom and lack of time to learn concepts thoroughly. Of those that held positive views about mathematics, the key contributing factor was that they perceived themselves as successful, which in turn raised their confidence and self-esteem.

Mr Ive found that teachers welcomed the original National Numeracy Strategy, which gave structure and confidence to their teaching, though they were finding the latest version of the strategy more difficult to implement fully. Integrating the ‘using and applying’ element into each unit, he said, was helping to make mathematics more relevant and realistic, and teachers also appreciated having more time to spend teaching a concept. Teachers were concerned that high expectations and the need to meet targets can mean that they teach objectives before students are ready, which increases their anxiety and reduces their confidence and self-esteem. In order to create a world class STEM workforce with the emphasis on mathematics, mathematics teaching has to be engaging and relevant for all students from an early age.

The study showed that there was a tendency to promote a transmission style of teaching, which relies on an over technical approach. He said that whilst skills do need to be taught in a logical way, many students want less input from their teacher. He felt that there was a need for clear, precise learning objectives framed as questions, which lead students into more exploratory activities. This could promote social interaction, which students find very supportive of their learning. The status of formative assessment, he said, needs to be enhanced in order to reduce the pressure on teachers to teach concepts before the students are ready. The right degree of challenge and support is vital, as is making learning fun and memorable. It is also essential to make mathematics teaching relevant to their lives, to link it to previous learning, and to show students how mathematics can help them make sense of their environment and thereby increase their power over it, which can be a powerful motivator in increasing a child’s desire to understand.

Mr Ive closed by saying that steps are being made in this direction, but teachers need to have the courage to ensure the love of learning mathematics is their first priority.

5.3 Karen Spencer, Vice Principal (Curriculum & Quality), Kingston College, Surrey

Ms Spencer represented Kingston College, a large Further Education College, with 10,000 students, 1800 of which study the STEM disciplines. The schools of engineering, science, mathematics and computing comprise one faculty, which allows effective links between
disciplines, and mathematics is taught in such a way that it underpins the other disciplines. She said that one of the reasons the college’s provision had remained healthy, was that it had maintained effective progression routes, from entry level through to Level 4. She noted that the college was involved in piloting qualifications such as GCSE Use of Mathematics and Functional Mathematics.

Ms Spencer said that parents, students and employers are confused about the changes in mathematics education and that effective communication mechanisms are needed to inform people about where the current mathematics offer sits in this landscape. Employers, she said, need something with currency, something that is valued and that they understand, but colleges are not in the position to offer that to them because they are unclear what is available, how to deliver it, and what the differing market demands are. Diplomas are adding to this confusion because colleges are unsure how these fit into their provision.

5.4 Dr Ian Gibson, Director, Space Technology & Industrial Policy, British National Space Centre

The British National Space Centre runs the national civil space programme. One of Dr Gibson’s aspirations was to develop UK’s share in the £120 billion global space market from 7.5% to 10%. It is a very highly skilled industry, he said, and requires very competent STEM graduates. Space, he said, is a subject that could be used to inspire and motivate students. The UK has 6500 specialist jobs in space technology, delivering around £750 million every year, mainly in building systems and satellites. A lot of small- to medium-sized companies make up the bulk of that market, staffed primarily by PhD graduates. This, he said, is a great focus for taking forward the economy in the right areas. He also said that because space is a global endeavour, it is important to produce graduates who can speak foreign languages.

The other side of the industry, said Dr Gibson, is the future market for space tourism. The UK could have a share in this service-driven side of the industry in terms of insurance and ticketing, but in order to understand the services that the UK can deliver, it must understand the systems side of the industry.

5.5 Jessie Seal, Council Member for the South West Region, English Secondary Students’ Association (ESSA)

ESSA is a student-led organisation set up by a sixth form student, with the mission statement of giving students a voice, empowering young people and providing them with the support and help that they need to effect change. Ms Seal had asked her peers about their opinions of mathematics and realised that many of them did not see the importance of getting a good
grade at GCSE until after they leave school. She also raised the issue that the amount of content in the curriculum left no time for consolidation of prior learning, particularly for students expected to attain high grades.

Ms Seal suggested that a way to combat the challenges of mixed ability classes would be a student mentoring scheme, set up by the school to allow struggling students to get help from older, more experienced students who had been given the necessary training. This would also be of benefit to the mentor as it could stretch talented students and consolidate their learning.

She said that gaining feedback from students about their learning, either informally in lessons or through student councils, forums or questionnaires, is an important tool. This feedback could lead to improvements in teaching. However, she pointed out that for these things to be effective proper funding needs to be put in place.

5.6 Question and answer session

Celia Hoyles commented that she was intrigued by Ms Seal’s point about peer mentoring. She said that the idea does have potential but that the NCETM would have to look at how it could be done within a constructive framework.

Q. How should Assessment for Learning be used to teach mathematics?

Teresa Smart: This was in development and was currently being piloted. She hoped to see it being rolled out nationally.

Steve Ive: Teachers should take into account where their students are up to when planning lessons, rather than preparing lessons weeks in advance. This sort of dynamic planning would improve mathematics and the engagement of children considerably.

Q. How can we move to a situation where mathematics is something that is done by students and with students, rather than something that is done to them?

Karen Spencer: It takes a great deal of professional confidence to enrich and motivate by taking a step away from the structures of the curriculum and still feel confident that students will meet the required targets.
Jessie Seal: From a very early age students are labelled as either a failure or a success at mathematics. Students need to have flexibility of progression and learning.

Dr Ian Gibson: Current studies were looking at what happens between ages of 10, when enthusiasm is at a peak, and the age of 16.

Q. Is there a policy to equip all classrooms with an internet connection and projectors so as to enable teachers to bring the world into the classroom?

Teresa Smart: It was certainly a drive under the STEM agenda that classrooms should have internet access. However, she said that research had shown that having the internet and interactive whiteboards in the classroom does not necessarily lead to a change in pedagogy and a strengthening of mathematics. The use of technology in the mathematics classroom must be accompanied by CPD for teachers.

Q. Did Mr Ive’s study look at the teachers’ pedagogy and what positions they allowed or encouraged in the classroom? When students leave school, the problem is not one of mathematical ability but of their attitudes toward mathematics. If students have the idea that they are not good at mathematics they will adopt a position within the classroom that interferes with their learning, however well they are being taught.

Mr Ive had tried to triangulate his findings by giving teachers questionnaires and by interviewing teaching assistants. He found that pressure to meet targets created anxiety in the teachers, which affected their teaching style, and this filtered down to the students. He said that the attitude of the teachers and the pedagogy that they adopt are key to forming the attitudes that the children take with them into mathematics.

6 The view from the Innovation, Universities and Skills Select Committee

6.1 Phil Willis, Chair, Innovation, Universities and Skills Committee (IUS)

Mr Willis thanked ACME for the work they had done in creating an interface between Government, policymakers and practitioners, saying that the six years since they were established had been hugely influential to the cause of mathematics education.

Mr Willis said that the UK must not lose sight of the fact that its international competitors are producing mathematics graduates and post doctoral fellows in a quantity and a quality which enhances their competitiveness, pointing out that the majority of postgraduate students and
academics in UK universities are now from China, Korea and India. Mr Willis said that the UK’s performance in International Mathematics Olympiad had severely declined in the last decade. This, he said, was a reminder that the teaching of mathematics in schools must encourage the most limited and, more importantly, challenge the most talented, which was why Mr Willis was so pleased that ACME took such a positive and aggressive stance on the inadequacies of the mathematics component in many of the new Level 3 diplomas. He fully supported the Tomlinson Agenda and the vision for advanced Level 3 diplomas. The new diplomas, he said, offer the prospect of academic rigour with vocational opportunity, but there is a danger of short-changing students, universities and, ultimately, international competitiveness if mathematics is not made a mandatory part of all Level 3 diplomas.

There remained in Government, said Mr Willis, a failure to understand the importance of high level mathematics for world-class technical and scientific skills, which was evidenced by the fact that a lack of mathematical knowledge was hindering undergraduates studying science and engineering and that fewer students were applying for those degrees. This would be compounded by allowing students to abandon mathematics at GCSE and yet qualify to study undergraduate STEM courses through technical diplomas. Rather than dumb down expectations of young people in mathematics, he said, the bar should be raised even higher. Further investment is needed for the network of further mathematical centres and the NCETM in order to ensure that support is available to students and teachers. Nobody rises to low expectations, he said.

Mr Willis congratulated the Government on giving attention to the place of functional mathematics within the curriculum. What had emerged, he said, was the realisation that mathematics must be at the heart of the UK’s drive for global competitiveness. The importance of mathematics and technical skills in today’s world should not be underestimated.

Mr Willis summed up the progress since 2002:

- Celia Hoyles and her colleagues, as well as academics and mathematics practitioners, had significantly raised the profile of mathematics teaching and engagement;
- the network of mathematics and computing specialist schools;
- the developments based on the recommendation of the Smith Report;
- a network of specialist organisations producing materials to support pedagogy;
- ministers who genuinely take a greater interest in mathematics teaching than ever before.

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He said, however, that the pace of change was too slow, vision was too limited and the curriculum and target-led culture continued to stifle innovation. Mr Willis related some worrying trends: the UK ranked the twenty-fourth in the Organisation for Economic Cooperation and Development league table for mathematics abilities of 15-year-olds; in 2007 45% of 16-year-olds failed to achieve grade C in mathematics; students were making little, if any, mathematical progress during Key Stage 2; fewer students were studying mathematics at university than ten years ago; the supply of graduate mathematics teachers had begun to move in a positive direction since 2004, but progress had since stalled; and recent figures showed a 15% decline in applications for mathematics Post Graduate Certificates in Education compared with the previous year.

Mr Willis said that recruitment and retention was a key issue still to be solved. He said that there was currently no definition of a specialist mathematics teacher and that the DCSF did not know how many primary mathematics teachers had mathematics qualifications, which made it impossible to plan the workforce. The ‘Golden Hello’

10, he said, is not sufficient to compete against the financial incentives offered in the financial services industry and other professions. The key to attracting mathematicians to teaching, he said, is to allow teachers to teach mathematics creatively rather than as a sterile discipline. Mathematics, he said, is a language that could transcend national boundaries, cultures, age, scientific fields, industrial sectors and time. Teaching mathematics is about the connection of mathematics to big issues such as the environment, energy, transport and health, and about its use in the media and the creative arts, in complex IT systems and in sciences. These, he said, rather than league tables, would excite and motivate young people to be involved in mathematics rather than simply being recipients of the discipline. Crucially, he said, it would inspire teachers to think differently, creatively and inspirationally about how they want to lead learning. Teachers need to be free to move outside the boundaries of the syllabus, but there must be an incentive to experiment and take risks. Mr Willis also said that teachers of mathematics need to escape the yoke of central direction and begin leading their discipline, particularly at Key Stage 1, an idea that he hoped would come out of Sir Peter Williams’ report into primary mathematics.

Mr Willis was applauded when he implored policymakers not to introduce more national strategies. Children should be allowed to discover mathematics in the same way that they learn to use language and to recognise shape, form, colour and texture through play. Mr Willis concluded by saying that conformity had not given mathematics education the breakthrough that it needed, so innovation was necessary.

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10 The ‘Golden Hello’, which was introduced in 2000 by the Government, is part of a package of incentives that aim to ‘encourage potential teachers to train and take up teaching roles in schools’. For more information: www.tda.gov.uk
6.2 Question and answer session

Q. Why was it important to know the numbers of teachers with A Level Mathematics?

A. Mr Willis was interested in how to best plan the workforce, saying that it is important to have a balanced workforce within primary schools. He was concerned that a lack of mathematics specialists would hinder the effective planning of an integrated mathematics curriculum. He said that specialists need not be mathematics graduates, but people with a grasp of the discipline, who understand where mathematics fits into a broader spectrum, particularly in primary schools.

7 Afternoon workshops

The purpose of the workshop sessions was to find out what views were held about the STEM initiative, particularly how useful it is to promote mathematics within STEM, how to give teachers confidence to teach STEM in a cross-curricular way, the recruitment and retention of STEM teachers, the mathematics content of the STEM diplomas, the content and format of the STEM directories, how to promote further education and careers in STEM to students and equipping learners at age 14 with the skills necessary to study STEM qualifications (GCSE/Diplomas). Groups were given a theme and were led by representatives from stakeholder organisations.

7.1 Summary of workshops

Group 1: Curriculum coherence, led by Sue Pope, Programme Manager, Mathematics, QCA

1) Concerns were raised about the time teachers need to be able to fully take advantage of the opportunities that STEM might offer to the curriculum.

2) There was a strong consensus that STEM should be for all learners, as part of their curriculum entitlement and that mathematics had a crucial role to play in STEM.

3) There were concerns about the assessment of mathematics and the fact that mathematics GCSE was the gatekeeper for so many pathways.

4) The group raised the issue of developing positive attitudes in all learners, so that regardless of their achievement at age 16, they feel able, confident and happy to continue with their study of mathematics.
5) They were concerned about the status of mathematics generally within the curriculum and the fact that it requires specialist provision and resources.

Group 2: Linking, engaging and stretching, led by Nigel Bufton, Programme Director for Mathematics, Primary National Strategy

1) The group felt that clarity is needed about the position of primary mathematics within the STEM agenda.

2) It was felt that teachers need deep subject knowledge in order to be creative and confident. They need to see the big picture, but also the detail, in order to deconstruct the mathematics in the primary curriculum sufficiently well as to be able to teach children the mathematics that they need in order to progress to the next level. This would enable teachers to identify where the barriers to learning were and to develop strategies to overcome them. Teachers need to know mathematics beyond the primary curriculum, to Key Stage 3 and possibly beyond, but not necessarily an A Level qualification. There was a need for CPD in this area.

3) Out-of-school CPD is important because it has a role to play in inspiring and providing that impetus to go away and do some mathematics. It was felt that in-school CPD could include mentoring, coaching, and having the opportunity to work with professional colleagues in the classroom to begin to unpack some of the mathematics.

4) Mr Bufton noted that there was no incentive for primary teachers to study mathematics at a higher level, either in terms of finances or professional acknowledgement. There was no obvious pathway to encourage people in primary schools to study mathematics for mathematics’ sake, with the aim of possibly establishing a mathematics leadership role in primary schools.

5) The group had differing views on mathematics as abstract subject versus mathematics in real life. Some felt that there was a need to start with abstract concepts before applying them to real-life situations, and that application could be a way to stretch learning. The key to knowing whether to approach learning as process or in context is subject knowledge. Teachers need to be flexible in order to inspire children and to make mathematics interesting to them.
Group 3: Assessing the value of STEM, led by Teresa Smart, Programme Director, Mathematics, Secondary National Strategy

1) The group discussed collaborative cross-curricular projects and how time could be made available for teachers to do this in a structured way.

2) They discussed the exciting STEM activities and resources that already exist, saying that industry could have some interesting ideas and money to help develop resources.

3) The group discussed whether it was acceptable to only use off-the-shelf enhancement resources, but decided that sometimes there is inherent value in teachers developing resources for themselves. This could help teachers to recognise quality ready-made resources.

4) Is there any point in changing teaching methods if assessment is not going to change? They felt that much could be learnt from the other STEM subjects, which had much more experience with assessing project work.

5) They thought that leadership is needed in schools to support the STEM agenda. One person should be the point of contact for STEM, both in terms of disseminating information and driving cross-curricular collaboration.

6) Finally, teachers should share good practice related to cross-curricular projects through the NCETM portal.

Group 4: Developing transferrable functional skills, led by Colin Matthews, Executive Director: Schools, NCETM

1) The group talked about developing and nurturing functional skills. They said that it was important to recognise mathematics as a beautiful subject, which, if taught appropriately, would allow mathematicians to solve problems that have not been invented yet. It was not enough, they said, to deal with functional mathematics, but there was a need to explore pure mathematics as an important subject. Functional mathematics should be as flexible and constructive an assessment tool as possible and the assessment tool will shape the teaching. The danger is that if students have to tick boxes and give yes or no answers they will not be mathematically functional, they will just rote learn the skills necessary to pass the exam.

2) Mathematics must retain its own integrity within STEM whilst respecting the integrity of the other disciplines. Mathematics must not subsume itself to be part of STEM; it must
maintain a discrete, stand-alone position, for example there should not be STEM departments where mathematics is a co-pilot.

3) The group felt that STEM diplomas did not have appropriate mathematics content to allow progression to university courses. They said that it is important to understand that a diploma course is a mathematical pathway, which must be able to ensure a smooth transition between, say, a B at GCSE and the requirement that is placed upon that learner mathematically when they enter a higher education institution. The diplomas have an obligation to progress learners who are engaged with them mathematically.

Group 5: Putting added value in STEM teaching, led by Yvonne Baker, Chief Executive, STEMNET

1) Generally there was support for the Government promoting the idea of STEM, but there were concerns about the law of unintended consequences. They pointed out that primary education and further education were cross-curricular, whilst secondary education and higher education were not. Curriculum design, they said would still continue to be separated into science, technology, engineering and mathematics.

2) The group agreed that there was a rich potential in the developed Key Stage 3 programme of study, and that mathematics departments should be asking for assistance with STEM activities to help inspire the students in mathematics. They saw this as a huge opportunity for teachers.

3) They raised the issue of communication, saying that it is not always safe to assume that messages are getting through to the relevant staff in schools and colleges.

4) It is important to take away the fear that teachers have of not hitting targets because they have been engaging in STEM activities.

5) They thought it would be useful to have a target about student voice, something that the DCSF was currently looking at.

Group 6: Mathematics enrichment – new directories for increasing access, led by Vinay Kathotia, Clothworkers’ Fellow in Mathematics, the Royal Institution of Great Britain

1) The group felt that the most important issue was time: time to prepare and gain ownership of STEM activities, and an understanding of how much time was needed for the planning and delivery of activities. CPD is needed in this area.
2) They also felt that it is important to have the opportunity of working collaboratively and to share good practice.

3) From the discussions about what should go in the directories, it was clear that it would be a contentious issue.

4) There were concerns about quality assurance and evaluation.

5) They felt that the directories should aid and ease the teacher’s use of STEM activities.

6) In terms of the format of the directory, it was felt that there should be an online version.

Group 7: Enrichment and Enhancement – looking out from mathematics, led by Annette Smith, Director of Regions, British Association for the Advancement of Science

1) The group felt that enrichment and enhancement are not necessarily just for the most able. Rather than being perceived as a treat for gifted young people, it should be available to all learners.

2) The directories should be easily searchable, with resources being tagged to link them to the National Curriculum.

3) The group raised the issue that maybe teachers are reluctant to do E&E activities because they do not like taking risks. The counter argument was that sometimes those teachers who are less confident may be more likely to try working in a different way.

4) How might cross-curricular learning work in a real situation? Is it likely to be mathematics reaching across to the other subjects, or vice versa? Perhaps there is a need for both.

5) It would be useful if careers information were available for specific subject areas. For example, at the end of a lesson on sine waves, it would be useful to provide information about how sine waves are used in real work. Real examples of mathematics going on in the real world can be very valuable and would be more useful if seen in context rather than in a careers department.

Group 8: Enrichment vs acceleration, led by Charlie Stripp, Programme Leader, Further Mathematics Network

1) They felt that enrichment should be an entitlement to students and that enrichment would potentially be destroyed by assessment.
2) They discussed enrichment schemes that were already available, but said that they needed to be exploited more.

3) STEM is a new idea for many school teachers, they said, so it is vital to promote mathematics to both teachers and students as part of STEM.

4) They were concerned that teachers did not have a clear idea about functional mathematics.

5) They felt that good links between schools and colleges would give secondary students access to good careers advice.

Group 9: Developing educational pathways, led by Jackie Rogers, Senior Subject Officer, GCE Mathematics, AQA

1) There was a concern that the general public may not understand the plethora of pathways available to 14- to 19-year-olds and how they all fit together.

2) The group felt that more mathematics should be built into the diplomas in an integrated way that is relevant to the students and to which they will respond.

3) There were concerns about timetabling mathematics, either alongside or within the diplomas in schools and colleges, particularly with regard to functional mathematics. They felt that there should be a stand alone functional mathematics qualification.

4) They discussed the fact that functional mathematics was intended to be a hurdle to the new gatekeeper GCSE, and there was concern that this may result in a significant number of students failing to gain grade C because they have not achieved Level 2 functional mathematics.

5) They agreed that language can sometimes be a barrier to students when they are confronted with problem-solving questions.

6) They also said that teaching and learning really should come first, rather than starting at the assessment and working towards it. This, they said, had CPD implications.

Group 10: Development of the new Engineering Diploma, led by Professor Nigel Steele, Council and Board member, Institute of Mathematics and its Applications

1) This group discussed the design of the engineering diploma. Fred Malliardet from the Engineering Professors Council told the group why the engineers welcome the diploma
and how important mathematics is in the diploma. His task group was concentrating on the diploma as a route to further study and had therefore looked at the mathematics component. The 60 hour unit was inadequate, so they had 'hijacked' Loughborough University's access course in mathematics, which was being worked up into a 180 hour unit to serve that purpose. There were still some concerns about raising the mathematics capability of people who do not take that unit. The group also learnt from Mr Malliardet that two other technically based diplomas were interested in using this unit for their own diplomas; however the LSC funding cap would not allow students to study additional qualifications.

2) The group looked at the further resources that were needed to deliver the diploma. They welcomed the help from the Mathematics in Education and Industry (MEI) and from the Further Mathematics Network in supporting teachers and said that there was a great deal of opportunity to link CPD and industry, for example teachers finding out where the subject can lead. Sound careers information for students was just as important to allow them to see the opportunities that a STEM-based degree gives them.

3) There were signs that cooperation between higher education and colleges and schools was happening, but more needed to be done.

4) In terms of demands on teachers, they need help and support in order to pursue and achieve CPD.

7.2 Question and answer session

Q. Inviting speakers from universities, for example, can have an immediate effect on recruitment into A Level Mathematics because of their enthusiasm about mathematics and its applications, but how might the costs of having these visiting speakers be met?

A. Grants are available from organisations such as the London Mathematical Society (LMS) and the Institute of Mathematics and its Applications (IMA). These bodies, and others such as MEI and the Millennium Mathematics Project, needed to unify in order to disseminate information about these sorts of grants, perhaps as part of the STEM directories.

Professor Smith added that, in addition to funds that were known, there may be less obvious avenues to pursue, for example professional bodies such as the Worshipful Company of Actuaries or the Institute of Chartered Accountants, which might be interested in providing either finance or other resources, since improving the mathematics skills of graduates would benefit them in the long term.

Nigel Steele: The IMA and the LMS both have web-based school speaker schemes.
Yvonne Baker mentioned the STEMNET Science and Engineering Ambassadors programme, a network of 18,000 scientists and engineers who offer their time, enthusiasm and expertise to help schools inspire young people for free. There was potential to include mathematicians in this programme.

Q. With DIUS developing a new adult numeracy strategy, is ACME considering whether there is a need for the adult population to progress in skill levels beyond Level 2, and should this be a priority?

Margaret Brown: ACME was looking at Level 3 functional mathematics and was pressing its role both in diplomas and for the adult population. ACME thought that Level 2 was not enough to make people fully numerate for life.

Sue Pope: The UK had signed up to European competencies, which are at a much higher level than Level 2 functional mathematics.

Comment from the floor: There was a need to look at funding for adults to learn at Level 3.

8 Adrian Smith’s closing remarks

Professor Smith restated ACME’s role as a think tank to influence Government strategy and policies, with the aim of achieving all the goals and aspirations of the mathematics community, and said that it would treat the next three years as a new phase of activity. ACME must focus on the big strategic issues of the supply, retention and training of teachers, the structure and content of curriculum, and the issues in and around assessment and the implications of assessment.

The landscape had changed, he said, since ACME was founded. He thought that the DCSF and the Government would see a separation between the operation and delivery through the NCETM and the more strategic role of ACME. This, he said, must be seen against the backdrop of STEM, which was a high priority for the Prime Minister, who a few years ago launched a ten-year initiative promoting science and technology as vital for underpinning the economy and wealth creation. Professor Smith said that although concerns have been expressed about the M in STEM being an afterthought, at least it does now have an M in it. ACME must watch very closely all the initiatives being launched under STEM so that mathematics benefits from being part of the agenda. ACME would aspire to speak with one voice for the mathematics community, working with colleagues associated with that wider STEM agenda, partly because it was a Government expectation and partly because of the potential to tap into useful resources.
ACME, he said, would continue to maintain close links with the DCSF and the DIUS. The mathematics community must build more links with the wider community, for example the Royal Academy of Engineering and the Confederation of British Industry, in order to influence Government in matters of mathematics education and to harness that support and energy, perhaps looking more into the international domain.

ACME’s working practices would be proactive and forward looking, trying to understand and influence policies before they are set in stone, rather than taking remedial measures or criticising after the fact. The work would continue through meetings with ministers, officials and key organisations, as well as making much more proactive use of the ACME website. One of the recurring themes, he said, was communication: ACME would continue to build an effective communication strategy, from the top down and through regular dialogue and interaction with the practitioner community.

Professor Smith summarised the key issues on which ACME would continue to work:

- making the directories project proactive
- monitoring the role of mathematics in the Level 3 diplomas, not just in Engineering, but also the planned humanities and science diplomas
- acting on the outcomes of the Sir Peter Williams report on primary mathematics
- monitoring and stimulating the supply of mathematics teachers
- formalising a system of entitlement and accreditation for CPD.