

# Science and Learning

## Consultation Response Form

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**Please tick if you want us to keep your response confidential.**

Name Nick von Behr  
Organisation (if applicable) Advisory Committee on Mathematics Education  
Address: The Royal Society  
6-9 Carlton House Terrace  
London  
SW1Y 5AG

If your enquiry is related to the policy content of the consultation you can contact Rory Gallagher (DCSF) or Alex Morris (BIS):

Rory Gallagher  
Telephone: 0207 925 5631  
email: [rory.gallagher@dcsf.gsi.gov.uk](mailto:rory.gallagher@dcsf.gsi.gov.uk)

Alex Morris  
Telephone: 0203 300 8723  
email: [alex.morris@bis.gsi.gov.uk](mailto:alex.morris@bis.gsi.gov.uk)

If you have a query relating to the consultation process you can contact the Consultation Unit on:

Telephone: 0870 000 2288

e-mail: [consultation.unit@dcsf.gsi.gov.uk](mailto:consultation.unit@dcsf.gsi.gov.uk)

Please mark ONE box which best describes you as a respondent.

<input type="checkbox"/> School Sector	<input type="checkbox"/> Further Education Sector	<input type="checkbox"/> Higher Education Sector
<input type="checkbox"/> Employer	<input type="checkbox"/> Science Association/Body	<input type="checkbox"/> Union/Professional Association
<input type="checkbox"/> Local Authority	<input type="checkbox"/> Training Provider	<input type="checkbox"/> Parent
<input type="checkbox"/> Young Person	<input checked="" type="checkbox"/> Other	

Please Specify: Advisory Committee on Mathematics Education (ACME [www.acme-uk.org](http://www.acme-uk.org) )

### Preamble

All ACME's answers to the consultation focus on Section 4 questions for 'all other respondents' though clearly there are areas of overlap with the other 3 sections. We are also assuming that all the questions refer to mathematics as well as science and engineering and we note that other respondents may not have made the same assumption so this may influence the number and quality of mathematics-based responses.

The main reference used for these responses are the numbered 'issues' from the Executive Summary of ACME's paper on a [mathematics education landscape in 2009](#) for the June 2009 DCSF/DBIS STEM High Level Strategy Group meeting (HLSG 1 etc). This paper in effect summarised a whole set of ACME positions on aspects of 5-19 mathematics education policy and each section, which covers a different age cohort, raised common and specific issues.

Occasional reference is also made to ACME's current proactive project on 'Mathematical Needs' which is divided into 2 themes: Theme A focusing on a 'top-down' analysis of the mathematical needs of Higher Education and employment and how these are best reflected in curricula and qualifications; and Theme B focusing on a 'bottom-up' analysis of effective teaching, learning and assessment in mathematics classrooms. However, since the project has only recently started it is too early for it to have any major influence on this consultation.

## **SECTION 4: FOR ALL OTHER RESPONDENTS**

30 What are the most effective ways of encouraging engagement, participation and progression in science/maths, particularly for the most promising students?

Participation in the study of mathematics in schools/colleges is influenced by a number of factors including gender, ethnic background, prior attainment, socio economic status, amount of choice available in the system, cultural attitudes etc. In short, it is a complex picture, shaped by a range of socio-economic factors. Some of these are barriers, some are encouraging factors. Moreover, there is still a noticeable gender difference in those studying and researching in mathematics post 16 onwards<sup>1</sup>. A key early factor influencing this are the course options made available to school and college students, the information, advice and guidance given to them about how these might suit their future needs and what encourages them to make the correct choice subsequently<sup>2</sup>.

There is a range of ways in which engagement, participation and progression in mathematics can be encouraged.

### *Perception of Mathematics*

The negative image of mathematics undermines attempts to encourage participation and progression, and will continue to require attention even though there are tentative signs that the situation may slowly be improving. As long as mathematics has a poor image amongst the public at large (and it is deemed acceptable to admit to being unable to do mathematics in a way which no one would admit to being unable to read or write), it will be an uphill struggle to widen participation and improve attainment. Attempts to raise the profile and importance of mathematics must continue to be a priority.

### *Mathematics Beyond 16*

It is widely perceived that England is one of the few advanced nations where mathematics is not a compulsory subject up to the age of 19. While recent rises in the numbers studying A-Level Mathematics and Further Mathematics are to be welcomed, there is still a concern at the high level of students who do not study mathematics beyond 16. ACME believes this is a situation which requires addressing – for the benefit of individual students, for the benefit of universities and for the benefit of

<sup>1</sup> See for example: [http://www.lms.ac.uk/activities/women\\_maths\\_com/statistics.html](http://www.lms.ac.uk/activities/women_maths_com/statistics.html) and [http://www.lms.ac.uk/activities/women\\_maths\\_com/statistics2003.html](http://www.lms.ac.uk/activities/women_maths_com/statistics2003.html)

<sup>2</sup> The following extract from QCA's Evaluation of Participation in GCE Mathematics report (November 2007 <http://www.ofqual.gov.uk/719.aspx>) highlights some of the more detailed issues at work: "Boys were significantly more likely than girls to say that they chose mathematics because of their university or career plans. Boys were very slightly more likely to give a reason that mathematics was more generally beneficial to have. However, girls and boys generally expressed this differently. Boys talked about mathematics being a 'good' subject to have and mentioned its being impressive on a CV. Girls were more likely to say the subject was 'useful'. Girls were significantly more likely than boys to say they had based their choice on previous success. They were twice as likely as boys to say that they chose mathematics because of their enjoyment of the subject. Girls were also more likely than boys to give the reason that mathematics complemented their other subjects."

employers, as it would significantly address many of the post-16 concerns with engagement, participation and progression.

### *Impact of Assessment and Testing*

While well-crafted assessment carried out skilfully should achieve its primary purpose of measuring achievement, and its secondary purpose of measuring accountability – it should also enhance and enrich the learning of mathematics. ACME supports the need to assess pupil progress and to have accountability measures in place. We also fully recognise that, following the initial introduction of Key Stage tests, there were significant improvements in standards.

While there are some welcome developments in the assessment of mathematics (for example using assessment for learning as in Assessing Pupils' Progress (APP) for Key Stage 1-3) there remains widespread concern that the current regime of high stakes testing is failing both in the primary purpose of assessment and is having a negative effect on learning. We are also concerned that the initial improvements in standards seen after the introduction of Key Stage 2 tests has now stalled.

The principal concern, which is of long standing, is that high-stake targets and league tables together with end of key stage tests drive teachers to 'teach to the test'. Following concerns about how pupils are all too often exposed to learning procedures and facts without learning the underpinning concepts, Ofsted<sup>3</sup>, in its most recent report on the teaching and learning of mathematics, recommended the QCA:

*“ensure current and future developments in external assessment place increased emphasis on pupils' understanding of mathematics and readiness for the next stage in their education, and avoid forms of assessment that fragment the mathematics curriculum” (p7).*

The problem is compounded by the restricted and predictable nature of test questions set. This means that instead of encouraging learning from a broad and rich mathematics curriculum, with open-ended investigations and challenging problems as well as mastery of essential techniques, understanding is restricted. Moreover, learners who are labelled as successful are not in fact able to transfer their learning to applications outside the formal mathematics classroom or able to move to more advanced learning.

As well as the external pressures mentioned above, difficulty is also caused by tests which are structured as if learning mathematics consisted of acquiring a set of specific skills which can be ticked off one by one using questions targeted at each skill in turn. Rather finely described 'learning outcomes' are specified and those constructing tests and examinations must demonstrate that each of these is explicitly tested. This approach is not consistent with how learners actually acquire mathematical understanding and the ability to fully harness the mathematics they know. There is no point in knowing how to do a particular piece of mathematics for a test if the pupil does not recognise or understand when it is useful.

### *Curricula and Qualifications*

A key element in overcoming the barriers will be played by ensuring that the

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<sup>3</sup> See <http://www.ofsted.gov.uk/Ofsted-home/Publications-and-research/Browse-all-by/Documents-by-type/Thematic-reports/Mathematics-understanding-the-score>

mathematics curriculum is engaging and relevant to pupils, as well as continuing to be valued as a rigorous intellectual discipline. There have been concerns that this is not necessarily the case in some aspects of the current curriculum, although recent reviews have provided an opportunity to take a fresh look at what mathematics is taught within phases of the education system.

*Ensuring a Qualified and Motivated Teaching Workforce*

Experienced and stimulating teachers play a central role in reversing negative perceptions of mathematics as a subject and in raising standards and rates of progression. Schools which experience frequent changes of staff or have a high proportion of inexperienced or non-specialist teachers are likely to have shortages in subject leadership positions. These departments often find it difficult to develop and share curriculum planning and good practice effectively. It also means that they play safe, teach conservatively and do not develop engaging new learning opportunities. With the right mechanisms in place (see answer to Q33) this can be overcome.

31 What are the major barriers to ensuring that young people feel engaged in science/maths and that those with the potential progress to more advanced levels?

Comments:

Many of the barriers are related to the issues raised in Q30 and potential solutions outlined in Q33.

32 Why, and at what stage in a young person's education do you think engagement of promising young people in science/maths reduces?

Comments:

The research evidence available to answer this question is variable<sup>4</sup>, and we would recommend that further work is undertaken to gain a better handle on when exactly young people may start to reduce their engagement with science and mathematics at an early age – though we note that research into the “key factors that shape patterns of participation, engagement and achievement in science and/or mathematics education by children and young people” is part of the remit of ESRC’s science and mathematics education initiative<sup>5</sup>.

ACME’s response to the Rose Review of the Primary Curriculum noted the following: “ACME has received anecdotal evidence to suggest that high attaining primary pupils may be lacking genuine mathematical thinking skills because of the limiting nature of the tests to which they are exposed.” This anecdotal evidence at least suggests there may be a problem with the mathematics engagement of promising young people. It is felt that the time which is devoted to ‘coaching’ students through the tests is a process which many students find stultifying and by the time they move on to secondary education their perception of mathematics has been harmed. To some extent this depends on the teacher, and to some extent on the ability of the rest of the class. In terms of the teachers, this relates to the barriers/solutions in the answers to Qs 30 and 33 under *Ensuring a Qualified and Motivated Teaching Workforce*. In terms of the students, some of them are and always will be committed to mathematics in spite of any uninspiring teaching because they just enjoy any work that involves numbers and algebra and feel confident they can do it and get teachers’ reinforcement while they see others struggling. However there are other students who may be gifted across a broad range but turn to non-mathematics subject because they are more interesting for them as presented in school. Anecdotally, this group are probably starting to get turned off mathematics by Year 6 and by Year 10 may well have been lost to the subject.

Again, more hard evidence is required to substantiate this view, but it is challenging to reverse this perception.

33 What suggestions do you have for overcoming the barriers to improving engagement, participation, and progression in schools and colleges?

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<sup>4</sup> See; the Royal Society’s ‘state of the nation’ report on science and mathematics education, 14-19, especially Chapter 6. <http://royalsociety.org/downloaddoc.asp?id=5698> .

<sup>5</sup> See: <http://www.esrcsocietytoday.ac.uk/ESRCInfoCentre/PO/releases/2008/may/investment.aspx>

Comments:

There is no silver bullet for overcoming the barriers to improving engagement, participation and progression in schools and colleges. Rather, there are a range of areas requiring attention which will support engagement, participation and progression. Some of the key areas are identified below.

*Perception of Mathematics*

Breaking down the negative cultural image of mathematics will require a holistic and long-term focus across a range of areas. In particular, championing the role of enhancement and enrichment activities within schools will help to challenge the misconceptions of mathematics by students and help demonstrate the wider relevance and significance of the subject. Moreover, improved careers, information advice and guidance (CIAG) which will illustrate the careers and higher education options available to those who study mathematics (particularly beyond 16). Part of the role is also being played by the media through TV programmes such as BBC4's The History of Mathematics and in US crime drama Numb3rs, which should not be underestimated for their role in raising the profile of mathematics and countering negative images in other media and from parents who had a poor experience of school mathematics.

*Mathematics Beyond 16*

ACME is working on a framework for a set of mathematical pathways in which there will be an expectation that mathematics should be studied by all beyond 16. This would require a major attitudinal shift towards mathematics which would reduce the large number of students who do not continue developing their mathematics education beyond 16. This would deliver benefits to students, university, employers and ultimately the nation as a whole. This would require a suite of Level 3 mathematics qualifications, such that each student could continue studying mathematics in a way which is appropriate to their learner needs. This suite of qualifications should include A-Levels and AS-Levels in Mathematics, Further Mathematics, Use of Mathematics and Use of Statistics, plus Free Standing Mathematics Qualifications (FSMQs) and a Level 3 Functional Mathematics qualification. With respect to other subjects (e.g. sciences, humanities etc), Use of Mathematics and FSMQs here have a major role to play in supporting the use and application of mathematics in other and differing contexts, and thus reinforcing progression routes.

*Impact of Assessment and Testing*

While there was widespread support (including from ACME) for the October 2008 decision to end statutory testing at the end of Key Stage 3<sup>6</sup>, ACME remains disappointed at the recent decision to retain end of key stage tests in mathematics at Key Stage 2<sup>7</sup>. ACME had previously submitted its views to the Expert Group<sup>8</sup>, and favours a move to a model which does not involve such high stakes testing, and the negative impact that this has on pupils' learning, motivation and enjoyment of the subject. We believe that teachers should have a much greater role in assessing pupils'

<sup>6</sup> However, we are concerned at the recommendation by the Expert Group that end of Key Stage 3 tests should continue to be developed.

<sup>7</sup> See [http://www.dcsf.gov.uk/pns/DisplayPN.cgi?pn\\_id=2009\\_0090](http://www.dcsf.gov.uk/pns/DisplayPN.cgi?pn_id=2009_0090) for the Secretary of State's announcement and <http://www.acme-uk.org/news.asp?id=135> for ACME's response

<sup>8</sup> See <http://www.acme-uk.org/downloaddoc.asp?id=114> for ACME's submission

progress, and there should be a move away from the targets and league table focus that currently surrounds testing at the end of Key Stage 2. ACME accepts the need for some way of monitoring national standards in mathematics and an approach involving sampling of pupils would be welcomed, as endorsed by the Expert Group.

Some specific comments relating to assessment appear in later sections of this report where relevant. However, ACME has on several occasions set down its own recommendations for assessment in mathematics<sup>9</sup>. Particular suggestions repeatedly made by ACME and by others which we believe would improve engagement in mathematics include:

- The importance of CPD needs to be recognised to develop teachers' ability to carry out formative (and in some cases summative) assessment and monitor their pupils' progress in a way which will enhance understanding, technical competence and ability to use and apply mathematics in all pupils;
- Strong support for a pluralistic approach to mathematics in the classroom, including open ended investigative work, group work and oral presentations. It may well be that such an approach cannot fit with formal external assessment, so the culture should be encouraged and supported by advisors and the inspectorate;
- More attention should be given to the validity of assessment (i.e. to ensuring that assessment structures are actually measuring the desired attributes). These include process skills such as reasoning, problem solving and modelling. Although these are written in to current specifications, their assessment is rarely adequate. ACME believes that a major reason for this is that it is extremely difficult to assess these skills in a short examination. There is a school of thought that says that with longer examinations greater validity would be possible; an alternative viewpoint is that longer examinations may not solve the problem and that quite different forms of assessment are needed. This concern is not new, and there is a considerable bank of evidence and experience upon which policy makers could draw;
- That, while modular examinations have many benefits, they can also lead to fragmentation of learning. This should be offset by more vigorous enforcement of requirements for terminal examinations to include some synoptic assessment.

#### *Curricula and Qualifications*

In order to ensure the curricula is engaging to pupils, ACME believes that moves to increase the focus on the use and application of mathematics, as is proposed with the primary curriculum (HLSG13) and the new pair of mathematics GCSEs (*HLSG 22, 23 and 24*) are to be welcomed. However, as a note of caution, urgent consideration is required on the impact that the move to two-tier in mathematics at GCSE may have on progression to Level 3 (HLSG 22).

We also believe that the process by which curricula are reviewed could be undertaken in a much more co-ordinated and structured way, over a longer timescale. Innovative contributions to curricula development and review should also be actively encouraged from a range of sources in order to create curricula which engage and enthuse students, for example through more cross-curricular opportunities in STEM and the

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<sup>9</sup> See <http://www.acme-uk.org/downloadaddoc.asp?id=40>, <http://www.acme-uk.org/downloadaddoc.asp?id=46> and <http://www.acme-uk.org/downloadaddoc.asp?id=114>

accompanying high quality continuing professional development (CPD) for teachers (see below)(HLSG 8).

It is also important that planned and co-ordinated proposals for CPD should be central to any new initiative intending to increase the engagement and take up of mathematics. The inclusion of the National Mathematics CPD committee in the planning stages of any such initiatives is crucial.

#### *Ensuring a Qualified and Motivated Teaching Workforce*

Ensuring that there continues to be a good supply of new teachers is a top priority. Current economic conditions appear to have resulted in sharp upturn in the numbers wishing to become teachers, with mathematics demonstrating a particularly strong rise. This must be welcomed with two notes of caution. Firstly, assuring the quality of teacher intake will be critical. Secondly, when the economy recovers, there will need to be a concerted effort on retaining teachers who may be tempted to leave the profession by a stronger private sector labour market.

In addition to recruitment, the delivery of effective CPD which improves the effectiveness and raises the confidence of teachers of mathematics will play a key role. ACME believes that the National Centre for Excellence in Teaching Mathematics (NCETM) continues to perform the lead role in this respect and the continued funding of this organisation beyond 2011 must be a priority.

34 What skills, qualifications and experience are most important for a school/college to be able to deliver effective science/maths teaching?

#### Comments:

This is a difficult question to answer, in that there is a range of differing skills, qualifications and experience required across the whole teaching profession, which will vary depending on the phase which is being taught (be it primary, secondary, further education) and also the subject-specific expertise of individuals.

#### *Skills*

It is imperative that classroom teachers of mathematics have the necessary level of mathematical *subject knowledge* and skills suitable for the phase of teaching that they are involved in. If they move on into senior management and away from teaching then it may be useful for them to keep their 'toe in the water' to understand the issues faced by their teaching colleagues.

Therefore, a range of issues remain critical, none more so than focusing on the recruitment and retention of appropriately qualified mathematics teachers (HLSG 5) to ensure a continued supply of new teachers in to the system. The current economic climate perversely offers a real opportunity to exceed the targets for recruitment on to initial teacher training courses.

In addition, the role of continuing professional development (CPD) – and the NCETM's role in this – must be central, as raising the quality of the existing teaching profession is key (as outlined in Q33). With a number of new initiatives in the pipeline – such as Assessing Pupils' Performance (HLSG 11), floated changes to assessment at Key Stage 2 and 3 (HLSG 19) and the need to upgrade teacher capabilities to deliver the teaching of expanded numbers on A-Level Mathematics courses (HLSG 31) and the 2 new paired GCSEs in Mathematics that will come into play by 2015 (HLSG 22) – CPD continues to be a central element of all attempts to raise the capabilities of teaching. Similarly, the roll out of the primary mathematics specialists in every primary school will play a major role in raising the standard of mathematics teaching, and should be speeded up, with funding secured beyond 2011 as soon as possible (HLSG 14).

#### *Qualifications and experience*

There is no fixed blueprint for the qualification and experience requirements of mathematics teachers. It is clear that these will vary between school and college personnel depending on their routes into teaching. There are however professional standards provided by sector skills councils, including TDA and LLUK for practitioners, as well as Chartered Mathematics Teacher status<sup>10</sup>, which reflects the balance between teaching skills (pedagogy) and mathematics knowledge that is necessary for a professional teacher to educate and inspire students. These should be supported, and teachers encouraged to engage.

In addition, the NCETM will play a continuing key role in maintaining standards in mathematics teaching (HLSG 5). NCETM, for example, has a self-evaluation tool<sup>11</sup> for teachers of maths to enable them to identify their skills needs and explore ways of continuously developing their mathematics content knowledge, mathematics-specific pedagogy, and embedding of content knowledge and pedagogy in practice.

Some mention has been made recently regarding the possibility of raising the initial teacher education requirements for teachers – the Williams Review looked at raising the entry requirements for primary teachers from grade 'C' at GCSE Mathematics to grade 'B'; and the Shadow Secretary of State, Michael Gove MP, recently floated the suggestion that achieving a 2:2 at undergraduate degree level should also be the minimum entry requirement for teacher training courses.

ACME believes that further work should be undertaken to explore the benefits of raising the initial teacher education requirements (HLSG 16). In particular, it is important to assess the relationship between degree classification and teacher competency but, perhaps more importantly, that the supply of graduates wishing to be teachers is not harmed as a result of raising entry requirements.

35 What are the most effective ways of providing young people with information, advice and guidance about higher education and careers in science and engineering?

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<sup>10</sup> See <http://www.ima.org.uk/cmathteach/index.html>

<sup>11</sup> See [http://www.ncetm.org.uk/self-evaluation/self\\_evaluation\\_intro](http://www.ncetm.org.uk/self-evaluation/self_evaluation_intro)

Comments:

There are a number of potentially useful resources already in existence which students (and their parents) can use, including the MathsCareers<sup>12</sup> and FutureMorph<sup>13</sup> websites. There are helpful resources, either as a first port of call or as an adjunct to a school/college careers adviser. However we maintain that there remain major issues about the quality of mathematics-related careers advice that the latter are able to provide. See also answer to Q30 on participation.

There are other bodies that will be able to comment in more detail on this question. We suggest that you seek further comment on this from the Council for Mathematical Sciences and the Science Council – indeed the Chief Executive of the latter body chairs the Science for Careers Expert Group, while the Project Manager of the HEFCE funded MoreMathsGrads project (which will come to an end soon) currently provides mathematics input to the group.

36 What more could be done to improve the skillset of science/maths students to help them progress successfully to pure science subjects and engineering in higher education and science-related employment?

Comments:

ACME believes that there should be mathematics curricula and qualifications offerings that support the teaching and learning of mathematics as a subject in its own right, but also support the mathematical needs of other subjects, including science and engineering, as well as those of employment.. But it is important to stress that mathematics plays a key enabling role beyond simply the STEM subjects, and to focus solely on science and engineering will miss the full range of subject opportunities at university, and employment prospects in the labour market which are available as a result of studying mathematics to a high level.

*Primary*

The current review of the Primary Curriculum has raised all kinds of issues about the way mathematics learning should take place in KS1 to KS2 and how it links forwards to the Secondary Curriculum and backwards to the Early Years Foundation Stage. ACME's paper for the Rose Review on 'Mathematics in primary years' said the following on skills: "The more utilitarian aims like contributing to the economy may seem a long way ahead of children in the early years, but all our research and experience suggest that for most children mathematics takes a long time to learn, so that they need to start early building up their knowledge and skills, as well as positive attitudes, to form a basis for later learning of mathematics and the other subjects which depend on it. So perhaps the key aim of learning mathematics must be to ensure that pupils leave primary school with the basic numerical, spatial and logical skills to enable them to access the whole curriculum in the next phase of their education."<sup>14</sup> As ACME's recent response to the DCSF/QCA consultation on the new primary

<sup>12</sup> See <http://www.mathscareers.org.uk/>

<sup>13</sup> See <http://www.futuremorph.org/>

<sup>14</sup> See <http://www.acme-uk.org/downloaddoc.asp?id=101>

mathematics programme of learning pointed out, many primary teachers lack confidence in and in-depth subject-specific knowledge of mathematics, even though they may have good generic teaching skills. So the impact of any curriculum changes will depend ultimately on tackling this, which in turn will be influenced by the proper implementation of the Williams Mathematics Review recommendations.

#### *Key Stage 4*

Further work is needed ensure that at Key Stage 4 students are being equipped with the right mathematical knowledge and toolkit to support progression to further study at Level 3 (be it in mathematics or mathematically-related subjects). It is important to focus on the enhancement of the ability of students to use multi-step reasoning and problem-solving confidently and appropriately and, more widely, to apply theoretical and conceptual ideas to real life contexts, both exemplified in good mathematics learning as would be taught in the pair of new GCSE's Mathematics to be piloted from 2010<sup>15</sup>.

It has been widely acknowledged for some time by some subject communities and by employers that the ability of students to use and apply their mathematics has been a weak element of the current mathematics curriculum, and the creation of the new pair of GCSEs is an explicit move to address these concerns, while at the same time aiming to motivate students who might react better to the subject being taught in an applied context. Our belief in the benefits of the pair of mathematics GCSEs is such that we continue to press for the speeding up of the introduction of the pair (without undermining the credibility of the pilot) (*HLSG 22*) and that, should the pilot be successful, the single GCSE should be discontinued (*HLSG 23*).

In the meantime, a worrying development within the existing (single) mathematics GCSE has occurred as a result of the move to the two-tier GCSE model. There is a fear that chunks of the GCSE curriculum are not being taught to students – perhaps as a result of the pressure to ‘bank’ a grade ‘C’ – which has the potential to seriously undermine progression on to Level 3 study. Urgent attention is required to address the extend of this problem (*HLSG 23*).

#### *Level 3*

ACME believes that a key aim should be to ensure as many people as possible continue to study mathematics beyond 16, at a level appropriate to individual learner needs. ACME will shortly be launching a piece of work which aims to provoke discussion on whether the study of mathematics should be an expectation for all up to the age of 19 (as we have mentioned earlier in Q33). This will reinvigorate the debate on mathematical pathways as promoted in Professor Adrian Smith's 2004 report, *Making Mathematics Count*, and outlines three possible pathways beyond 16, in which the study of a range of existing Level 3 (and some Level 2) mathematics qualifications will be possible by all those in full-time education and training (*HLSG 28*). It is our belief that moving towards such a model will benefit the individual students, as well as boosting STEM (and other mathematics-reliant) subjects at university and for employers seeking a mathematically competent workforce. We would urge the group to explore the benefits of moving to such a model at Level 3.

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<sup>15</sup> See <http://www.acme-uk.org/page.asp?id=122>

However, the existing Level 3 framework is currently being reviewed, and ACME produced a position statement in February 2009 on changes to A-Level<sup>16</sup>. Within this, the retention of the Advanced Extension Award is crucial for providing stretch and challenge to students without sacrificing accessibility (*HLSG 33*).

The move towards diplomas offers particular challenges to mathematics, especially at Level 3. ACME has previously published a position statement on the subject of mathematics in Level 3 diplomas<sup>17</sup>. Our concerns are three-fold. Firstly, we believe that there is simply insufficient mathematics in the principal learning element of the diplomas to provide even the most basic toolkit of mathematical understanding (*HLSG 34*). This has real and negative implications for the mathematical competency of those who progress through a diploma route. Secondly, a proliferation of bespoke mathematics additional and specialist learning (ASL) units should be resisted, as it would lead to severe added pressure on the teaching system. Instead, existing Level 3 qualifications – which have the benefit of a degree of ‘brand recognition’ should be employed to deliver the mathematics needs of the ASL (*HLSG 34*). And, thirdly, we harbour a major fear that in a future landscape which becomes dominated by diplomas, there may be barriers to traditional routes to studying mathematics (or mathematics related subjects) at university (*HLSG 35*). We recommend further work is undertaken to assess the extent of this risk.

37 What skills do you think should be developed further as part of a science education to enable young people to succeed in employment?

Comments:

We believe that an absolutely critical component of young people’s science education is a basic level of mathematics for all, especially a focus on the use and application of number<sup>18</sup>. There is no doubt that being mathematically competent is a key determinant of success in the labour market and a major component of progression into and through many higher education courses, as well as being a subject to study in its own right. In short, mathematics is a key enabler (*HLSG 1*).

As we have already outlined in the answer to Q36, a focus on functionality, and the use and application of mathematics must be central to any skills set of young people. The new pair of mathematics GCSEs – with one explicitly focused on using and applying mathematics – will equip students with some of these skills at Key Stage 4 (*HLSG 22, 23 and 24*). At Level 3, ACME is floating the suggestion that the study of mathematics to the age of 19 should be expected of all students (in a way which is appropriate to individual learner needs) and, as such, those studying STEM subjects will receive an enhanced training in mathematics than might previously have been the case.

It is not envisaged that, as part of this model, that all students will choose A-Level

<sup>16</sup> See <http://www.acme-uk.org/downloaddoc.asp?id=118>

<sup>17</sup> See <http://www.acme-uk.org/news.asp?id=91>

<sup>18</sup> Note: ACME does not find the terms ‘numeracy’ and ‘functional mathematics’ very helpful in themselves but accepts that they are recognised by employers.

Mathematics (or Further Mathematics), but it could be the proposed A-Level in Use of Mathematics or Use of Statistics, or a Free Standing Mathematics Qualification (FSMQ). ACME fully supports the development of the suite of Level 3 mathematics qualifications as proposed by QCA in its recent consultation (HLSG 29) but we are also calling for the creation of a Level 3 Functional Mathematics qualification to complete the set (HLSG 28).

38 What skills do you think society values in science students and graduates?

Comments:

A key stated aim for policy makers must be to ensure that all citizens have the ability to engage with an increasingly mathematical society, and that a major component of achieving this aim must be through the mathematics education of young people (HLSG 3).

However, while many people love the beauty of mathematics, and are comfortable deploying it as a tool of scientific analysis, we have to recognise that many people are repelled by even the thought of numbers, geometry, trigonometry, algebra and equations, let alone calculus. This undermines attempts to promote wider participation and higher attainment in the subject. Our most striking challenge is the readiness of adults to admit to being unable to study mathematics – or even reveal a genuine fear of the subject. It has become ‘cool’ to admit an inability to do mathematics, in a way which it would never be acceptable to admit publicly that one is unable to read or write. This has, on occasions, been exacerbated by some in the public eye making statements relating to their fear of and/or inability to understand mathematics. All of this means that efforts to promote improved attainment and widen participation in mathematics is undermined (HLSG 4).

That being said, employers value a range of mathematics-related skills in their workforce ranging from basic numeracy, through use of spreadsheets and data manipulation, right up to the highly technical areas. Moreover, skills such as problem solving abilities, perseverance and logic are also highly sought after and are commonly found in those with a high level of competency in mathematics. This is reflected in the oft-quoted figure that those in possession of an A-Level in mathematics earn roughly 10% more over their lifetime than those without mathematics A-Level.

One of the next major projects of ACME is to undertake research in to the ‘Mathematical Needs’ of the nation, in terms of the mathematics that is required on various pathways beyond compulsory education (i.e. in to higher education or in to employment). By being able to gain a handle on what mathematics university courses require, and what mathematics employers value the most, we aim to reflect back whether the current education system is equipping students with the mathematics required for progression in to higher education and the labour market.

39 How could links between schools, colleges, universities, employers and other institutions be improved to support engagement, participation and progression in pure science subjects and engineering?

Comments:

An improved mechanism is required between all these stakeholders for communicating about, and negotiating on differences of views on what is required from STEM education. To some extent this is already being achieved by the creation of the STEM Coherence Programme and clearly the DBIS Science and Society programme has added to further impetus through the establishment of its Expert Groups.