ACME Advisory Committee on Mathematics Education

Increasing provision and participation in post-16 mathematics

Rationale

In June 2011 the Secretary of State for Education set out a 10-year goal for the vast majority of young people to be studying mathematics right the way through to 18. ACME has been asked to explore the options available for making this a reality.

ACME's *Mathematical Needs* reports articulated the urgent need for action in this area, describing how the quantitative demands of almost all university courses are increasing, and noting that in the workplace the need for mathematical understanding has been amplified – not diminished – by the use of software.

The Nuffield Foundation report *Is the UK an Outlier?* found that the level of post-16 participation in mathematics was extremely low in England compared with other countries. More recently Ofqual's work on international comparisons noted that a range of levels of mathematics qualifications were available to students in many other education systems – in contrast to A-level Mathematics in England.

In England there has recently been some success in increasing the number of people studying beyond GCSE. Last year 80,000 people were entered for A-level Mathematics, and the numbers look set to increase to 100,000 in 2012. Further Mathematics is now one of the fastest-growing subjects at AS and A-level, and all of these courses fare very well in Ofqual's recent international comparison of qualifications.

However, despite these encouraging trends England still lags behind the rest of the world in terms of post-16 participation in mathematics, and the effects of this are being felt in higher education and in the workplace. Each year there are 250,000+ students who achieve a grade B or C at GCSE, but who do not, or cannot, take a mathematics course post-16. These students have achieved a good GCSE grade by league table standards, but in mathematics they are effectively disenfranchised.

Some students choose to study another subject rather than mathematics; some simply do not wish to continue their studies. However for others, access to a well-recognised qualification is effectively denied either because they have not covered appropriate content in a Foundation Tier GCSE, or because they did not gain a grade C or B at GCSE and are discouraged from taking A-level. A very few have access to the existing provision offered by FSMQs and AS level Use of Mathematics.

Put simply, the vast majority of young people have no widely-recognised way of continuing to study mathematics after GCSE. This paper considers how this situation could be changed.

Scope

This paper focuses on how to improve the numbers of people studying mathematics beyond GCSE and the choices they have, but we have chosen *not* to look at changes to A-level Mathematics itself or Further Mathematics. It is essential that in taking this agenda forward we do not damage the current trends in uptake; the more subtle question of how to make improvements to AS and A-level Mathematics is important but is not dealt with here.

We have also chosen to focus on the provision of qualifications for those who have already achieved at least a grade C in GCSE Mathematics. It is extremely important that appropriate routes are developed for those who have not achieved at this level – as argued by Professor Alison Wolf in her recent report – but this agenda demands separate attention.

Finally, we note that we are not starting from scratch. There are lessons to be learnt from recent initiatives – including FSMQs, Use of Mathematics, Diplomas and Key Skills. Neither are we operating in a policy vacuum – ongoing reforms to A-level, GCSEs and funding are relevant and there is a need for a joined up approach. Nevertheless, it is important to examine the options from first principles, and this paper seeks to do that.

Methodology

These issues have been discussed by ACME and within the mathematics community in various forms in recent years, but until recently it has been a 'mathematics issue'. In February 2012 ACME issued *Bridging the mathematics gap: Have your say* in order to prompt discussion amongst a much wider audience of how these issues could be tackled. The approaches described below have grown from the many responses we received to the consultation, and from related discussions in workshops this year with various groups, including awarding organisations. The paper has been produced in time for discussion at the ACME annual conference in July, and we hope that it will stimulate thinking amongst all stakeholders.

The following pages set out the five categories of approaches to tackling the problem that we have identified. A brief description of the advantages and drawbacks is presented in each case to stimulate further discussion with stakeholders.

The five categories considered in this paper are:

- Embedded approaches – 'Distributed mathematics'
- Fixed-programme approaches – 'Baccalaureate-type models'
- Single qualification approaches – 'Broadening AS-level Mathematics'
- Approaches to enable progression – 'Access to AS-level Mathematics'
- Pathways approaches – 'Alternatives to AS-level Mathematics'

None of the options described contain any fine detail at this stage – we have sought only to identify the defining characteristics and philosophies of the possible approaches. As such, there are several variations possible within each category, and these will be developed further once the preferred approach has been chosen. When reading this paper it should be noted that the options are not necessarily mutually exclusive – elements of some can potentially be combined with others.

Next steps

ACME intends to report back to the Department for Education in the autumn, with the aim of identifying a preferred category of approaches to be developed further.

None of the approaches is without risks and issues, and all have elements of merit to them. Like many policy issues, there is no obvious 'right answer'. To move forward, the options need to be balanced against each other, and risks and issues identified and then managed.

Essential requirements for success

Ensuring awarding organisations offer an appropriate suite of courses will not in itself result in an increase in either the provision of, or participation in, post-16 mathematics. There are other issues that need to be resolved in order to ensure schools and colleges offer courses and students elect to study them. School, college and student behaviours are affected by a complex system of levers and drivers, and these factors need to be balanced to achieve a significant increase in uptake of post-16 mathematics.

Irrespective of the approach(es) taken, we have identified the following essential requirements that need to be satisfied for any attempt to succeed in increasing participation in mathematics for post-16 students.

- The **qualifications structure needs to be clear and easily understood** by students, parents, teachers and end users. It is clear from our initial investigations that an overly complex set of qualifications would ultimately result in any new qualifications being undervalued by higher education and employers. We will be working with the Department for Education, the awarding bodies and the regulator, Ofqual, to explore how best to achieve the necessary clarity.
- Any new qualifications need to be overtly and clearly **valued by universities and employers**. Otherwise, we risk repeating the failure of past initiatives to increase uptake. It will therefore be crucial that those in higher education and employers are involved in some way in the development of any new qualifications. New qualifications need to be understood and required by university admissions tutors, and it is not easy for tutors to keep up to date with qualifications if they change regularly or exist in many varieties. This is a substantial challenge.
- Increasing the level of participation in mathematics generally means asking or requiring students to study an **extra qualification alongside their study programme**. This is likely to have consequences for the number of options students can choose when they start their post-16 studies and whether they can drop any after the first year of study. The extent of the potential changes to the overall programme of study for this stage of education needs to be thought through carefully and the implications for students and colleges need to be considered.
- The Department will need to ensure that **accountability measures** such as success rates do not act against the desire to increase the participation in post-16 mathematics.
- Only one of the approaches described above would make mathematics compulsory for students. Instead, students will have to opt-in, through making the choice to pursue the course. Although some students might make a negative ‘not mathematics’ choice it is more often the case that they positively choose another subject. The provision will need to be **engaging and motivating to potential students**. Students will also need to complete the course with a reasonable chance of success, and their decision to remain on the course for its duration will be affected by course content, delivery and assessment methods.
- **Initial advice and guidance** offered to the student prior to commencing their studies, especially at enrolment in August when qualification choices are made, will need to articulate clearly the benefits of new and existing courses. For example, **school and college prospectuses** will need to include appropriate information to aid decision making and positive statements about the benefits of continuing to study mathematics.
- Staffing issues will need to be resolved. For any increase in the uptake of post-16 mathematics, the **lack of suitable teachers will lively prove a significant problem**. Achieving the substantial increase needed in post-16 participation in mathematics across the full range of provision including GCSE Mathematics and A-level, will mean having a

larger workforce ready, willing and able to deliver new and existing qualifications. This is clearly cannot be achieved overnight, and the Department for Education will need to plan for a staged increase in the number of mathematics teachers. The Department will need to consider how many new staff are needed and when, and then how best to ensure the supply of staff. Professional development of existing staff is also likely to be required. The exact nature of this development will depend on the approach taken to increasing participation in mathematics.

How to engage

ACME intends to provide initial advice to the Department in October, and we would welcome your feedback to help us develop our thinking. We are particularly keen to encourage and enable stakeholder groups to discuss the issues presented in this paper and to receive summaries of such discussions. Where possible, we will try to arrange for one of the ACME Committee or its Outer Circle to attend such discussion groups. Please contact us via acme@royalsociety.org if you would like a representative to attend a meeting.

Various factors need to be balanced against each other and we would like to hear from:

- Students:
    - What would make a course attractive and useful?
    - Which approaches would have (had) the most or least positive impact on their overall study-programme post-16?
    - What information, advice and guidance would they have liked to receive and when?
- Teaching staff and senior management:
    - Are some approaches hard to justify because of staffing issues? There are competing demands on timetables for all types of centre. Fitting in a new mathematics qualification alongside AS-levels will provide a challenge. Are any of our approaches easier to implement than others?
    - How can we ensure that there is continuing professional development for teachers, so that every teacher capable of teaching both existing and any newly introduced mathematics courses is motivated and rewarded for taking up the challenge of doing so?
- Universities and employers:
    - Are any of the approaches identified more or less likely to result in highly valued qualifications?
    - How can universities and employers signal the importance of studying mathematics post-16?
- Teachers of other subjects and their representatives:
    - Which of these proposals would meet your needs?
    - Are there implications for the uptake of other subjects?
- Curriculum developers and awarding bodies:
    - Are any of the approaches more or less likely to be implementable in practice?

1. Embedded approaches

'Distributed mathematics'

Embedding elements of mathematics into other courses would enable many more students to study mathematics and quantitative methods until the age of 18 without taking a separate course or qualification labelled 'mathematics'. Mathematics would be studied and used in context, enabling students to apply mathematical thinking in their work or studies more readily. This approach could complement one or more of the other approaches outlined below.

Advantages and opportunities

- The overriding strength of embedding mathematical content into other subjects is that it should result in an increase in the number of students with experience of using and applying mathematics.
- This approach should enable students to understand how mathematics relates to the other courses they have chosen to pursue. There would be no impact on students' choices at 16+ as they would be free to build their study programme around existing qualifications.
- Quantitative skills are needed in many fields and this approach directly meets the need for students to have relevant mathematics included that is specific to that particular qualification. Such strong contextualisation can be motivating for students.
- Embedding mathematics would not preclude students from taking a separate qualification in mathematics.
- No new staff would be required, as normally all the mathematical elements of a course would be taught by the staff of existing courses.

Disadvantages and risks

- This approach does not ensure all students study some mathematics, as it would be inappropriate to introduce mathematics into some qualifications (such as English).
- A wide range of qualifications would need to be altered substantially to include relevant mathematics. There is no mechanism available to ensure mathematics content would be included. For each qualification, awarding organisations, universities and others would need to identify and then include appropriate mathematical content.
- It is likely that any new mathematical content and skills included in qualifications would be taught by the subject teacher, and not by a specialist mathematics teacher. This is a significant change and staff may require a great deal of professional development. Schools and colleges would need to have the resources in place to ensure students and teachers had access to extra support from specialist teachers.
- Students might also be left with a fragmented understanding of mathematics, limited to that covered in particular courses. Without coordination, there is a risk of repetition of content across several qualifications.
- Unlike the other for approaches outlined in this paper, this approach does not enable access to advanced mathematics beyond that taught in a specific subject.

2. Fixed Programme approaches

'Baccalaureate-type models'

Introducing a requirement to study a suitable mathematics course would significantly increase participation in mathematics. This would be achieved by constraining students' course choices in a coherent way[1], possibly within an overarching structure for their entire study programme. It could also be achieved, for example, with a qualification 'wrapper' around 2-4 small courses that sit alongside the rest of a student's programme. Such fixed programmes could include mathematics as a compulsory element, made available at a number of levels. It is noticeable that those countries with a high participation in post-16 mathematics generally achieve this with a fixed programme, often compulsory, approach to post-16 study. There is a range of models used in other countries, and in this country fixed programmes also already exist (BTEC, International Baccalaureate, Apprenticeships). New qualifications would need to be developed, and approaches 3, 4 and 5 describe potential qualifications that could be included in such study programmes.

Advantages and opportunities

- A Government taking this approach, or moving in this direction, would clearly signpost the importance and the role of mathematics to parents, universities, employers and students.
- Taking this approach would make the education system in England comparable to other countries that achieve high levels of post-16 participation in mathematics.
- Introducing a form of fixed study programme with compulsory mathematics, made available at a range of levels, would create the motivation to change behaviour in terms of school and college provision, and student uptake. This change in behaviour would be hard to achieve through signalling by universities and employers, for example with universities publishing preferred post-16 mathematics qualifications.
- Taking this approach would reflect and facilitate the trend towards local baccalaureates – encouraging the study of a balanced range of subjects.

Disadvantages and risks

- Introducing a fixed programme for post-16 study, including mathematics courses for all, implies a system wide reform. This would have implications for other subjects. System wide reform has a range of costs associated with it, making this approach potentially more expensive than the others described in this document.
- A fixed programme approach inevitably raises questions about what else, if anything, should be made compulsory. Further discussions with employers and universities would be needed to identify specific priorities.
- There is a risk that the focus would be on academic pathways; any changes to post-16 study programmes would need to consider both vocational and academic pathways.
- The need to offer a wider range of courses/options might not be practical in small institutions (and there is currently a trend towards smaller institutions).
- Near-compulsory study of mathematics (notably Key Skills Application of Number as part of the Curriculum 2000 reforms) has been attempted in the past and has clearly not been successful for a variety of reasons including the lack of currency of the qualifications offered.

[1] It should be noted that compulsory study can also be achieved by changes to funding mechanisms, but the approach described here is intended to describe the entire programme.

3. Single Qualification approaches

'Broadening AS-level Mathematics / Making AS-level Mathematics more accessible'

AS-level Mathematics exists, and is a respected qualification. Increasing take-up in AS Mathematics would increase the participation in level 3 mathematics. This could be achieved by reforming the qualification to make it possible for all students with a grade C in GCSE Mathematics (either tier) to embark on the course with a realistic prospect of success. The end point would stay the same. Currently Mathematics GCSE Foundation Tier (unlike most other GCSEs) doesn't cover the entire GCSE Mathematics Programme of Study. Enrolment onto AS Mathematics is a decision made both by the student as a consequence of their choices, and by the post-16 institution which sets entry criteria. These criteria are very likely to include a grade of B or higher for enrolment onto AS Mathematics. In practice many institutions require an A or even and A*, because it is feared, for good reason, that students are unlikely to succeed at A-level. Mathematics is exceptional among AS subjects in this respect, a reflection of the fact that it is among the very hardest subjects. This option would have the effect of levelling the playing field. This could be achieved in several ways, including encouraging the teaching of the AS Mathematics course over two years.

Advantages and opportunities

- Changes to mathematics courses would be made within an established structure, with no effect on other subjects (except possibly displacement).
- A-levels have recognised currency with universities and employers and are valued – provided the changes are accepted by these stakeholders there is no need to understand and value a new qualification.
- Even small providers should be able to deal with the delivery, as they do not need to get to grips with new qualifications.
- The necessary changes could be made as part of the current round of A-level reform.
- It is a simple solution that would be well understood by all stakeholders.
- A consequence of this change could well be a further increase in the uptake of AS (and A2) Further Mathematics.

Disadvantages and risks

- The very high spectrum of achievement in mathematics at any given age means that the task of redesigning and delivering AS Mathematics might be impossible. The gap between Grade C Foundation and AS-level may be too wide to bridge in two terms of study.
- If the end point of AS Mathematics is not carefully maintained, the currency of the qualification could be devalued, and the approach would not ultimately achieve the goal of increasing participation of mathematics.
- This model is predicated on the maintaining of (at least) the AS+A2 structure in the forthcoming A-level reform.
- Needs of those students taking AS currently would be compromised, and schools and colleges would need to have appropriate provision for a sudden influx of weaker students.
- Making AS-level Mathematics more accessible might result in pre-16 uptake and encourage inappropriate early entry to GCSE.

4. Approaches to enable progression

'Access to AS Mathematics / Steps towards AS Mathematics'

This approach is designed to enable and encourage students to continue mathematics as far as they wish, in the knowledge that they will receive credit for what they have achieved. It would provide suitable next steps for all students with GCSE grades from C upwards, so that, in contrast to the present situation, the choice between continuing mathematics and giving it up would be a real one. Furthermore, students would not be expected to choose between divergent mathematics programmes at the age of 16, a time when many are uncertain about their aspirations or where their talents lie.

The essential feature of this model is transition course located between GCSE and the start of AS-level, leading to new intermediate qualification(s). The intermediate qualification could be used in one or more ways:

- As a course in its own right.
- As a bridging course to AS Mathematics in the following year.
- As form part of a two year programme – see section 5.
- And/or run alongside AS-level – see section 5.

It is also possible that it could be used in all four ways.

Overall, the total new provision would allow various stopping points, with associated qualifications; some of these would be new intermediate awards and others, such as AS-level (and beyond), will be familiar. Students with good GCSE grades will not usually need to take the transition course.

The design of the transition course would be very important. At every stage the mathematics that students are learning, and the approaches to it, would need to be motivating and relevant to their current needs. As far as is realistic, it would support the mathematics typically required by other subjects; this would often involve basic arithmetic, algebra, statistics and graphs.

These are essentially the same areas of mathematics that are also important for students starting AS-level Mathematics and so the transition course would quite naturally prepare those students who opt to take that step. Most students would have already been taught all, or most, of the necessary work and half-know it; they need to build up fluency and accuracy. Importantly, they need to develop the confidence to engage fully with the subject for themselves; this too would be fostered by the transition course.

Advantages and opportunities

- Students would not have to make limiting choices by choosing between divergent mathematics programmes at the age of 16.
- This would make it more realistic for universities to include a post-16 mathematics qualification in their standard offers for prospective students.
- The changes could be made in conjunction with any proposed changes to A-levels.
- The current standard of A-level would not be affected.

Disadvantages and risks

- Considerable care would be needed with the design of the transition course.
- This approach would benefit from the maintenance of the AS / A2 split.
- The new qualifications would need to be assigned a Level intermediate between 2 and 3 (2.5) for funding and performance purposes, and to signal their status to students.

- The status of the new qualifications would need to be established.
- The new qualifications would need to gain recognition from parents, universities and employers. A period of stability would be needed to achieve widespread understanding and acceptance of a new type of qualification.
- Smaller centres may initially struggle to offer such a qualification in parallel with AS-level Mathematics and so the impact of its availability may be diminished unless suitable incentives are introduced to encourage these centres to offer such a qualification.
- Continuing mathematics to AS-level in year 2 of 16-18 study may not be viable for some students with a 3 A-level programme.

5. Pathways approaches

'Alternative parallel qualifications'

Alternative pathways qualifications have been available for some time (A-level Statistics, Advanced FSMQs, AS Use of Mathematics and the recent pilot of A-level Use of Mathematics) and were central to the Smith report and subsequent development and pilot work. Despite their availability they have had a patchy impact for various reasons, some of which are related to status and some are to do with implementation and support.

This approach involves offering a small number (potentially just one) of post-GCSE Mathematics qualifications in parallel with AS and A-level Mathematics. Such qualifications would need to be recognised and valued and there would need to be clear identification of their level in relation to A-level Mathematics.

There are many ways this could be approached. For example, these include:

- Using a transition course (like that described in approach 4) as a way of bridging to other (not the existing AS-level) advanced mathematics or statistics courses taken in a second year of study.
- Developing a limited number of one or two year 'Mathematics for …' qualifications. It should be remembered that the work on developing FSMQs was intended to avoid a proliferation of such courses.
- Introducing a generic problem-based course with a focus on mathematical thinking in context. There could be one or two year courses and it may be desirable to introduce a two-part course, with a common first year and a more specialised second year, when students have a clearer view of their intended next destination.

Whichever route(s) is taken, this approach would need to build upon lessons learnt from recent attempts at developing qualifications, and open to either the reformulation of these and/or the development of new approaches to curriculum and assessment. The size and shape of such courses also needs to be considered carefully.

Advantages and opportunities

- Developing a small number of pathways could provide scope for tailoring mathematics to the needs of the student. Courses with higher contextualisation and obvious relevance could be more motivating for students. Existing qualifications could be built upon as a route towards this
- This approach would draw upon lessons learned from recent experience rather than starting from scratch.
- As described in the fixed programme approaches, if these courses an AS-level or less in size they could be bundled with other key subjects (languages, English, the Extended Project Qualification) to occupy the 'fourth A-level' slot, providing scope for a rounded post-16 education.
- Additional pathways would offer students a genuine choice, with the potential to build in opportunities to transfer between pathways.
- New pathways could be relevant for students wanting to continue their mathematics beyond GCSE but who are not intending to a) go into higher education or b) study subjects with mathematical content.

Disadvantages and risks

- There could be potential for extreme proliferation of courses (‘Mathematics for ...’) which could be confusing and fragmenting for all stakeholders. Taking this approach would require a limit on the number of variations and strong coordination between awarding organisations.
- The range of possibilities means that it may be difficult to have a commonly available alternative pathway that is broadly supported, implemented and recognised.
- Similar attempts have had mixed success to date, as there have been issues of qualification status, university buy-in and funding and delivery issues that have proved to be highly problematic.
- Small providers may struggle to, or choose not to, offer a full range of alternative pathways, in the same way that they often cannot, or do not, provide choice of A-level applied modules or Further Mathematics. However, the success of the Further Mathematics Support Network indicates that with appropriate vision and support such obstacles can be tackled.