

Mathematics and A level Reform, an MEI position paper September 2012

Executive Summary

Mathematics is enjoying a period of sustained growth in A level entries and in recruitment to university degree courses where mathematics is a key component. Whilst changes should be made that improve the current A level Mathematics, great care is needed to avoid undoing recent gains.

The process of A level reform presents exciting opportunities, but unfortunately the Summer 2012 Ofqual A level reform consultation is problematic because it attempts to treat all subjects in the same way. The Curriculum 2000 experience provides ample evidence that changes that may be beneficial for some subjects can unintentionally be damaging for others. In particular, care must be taken not to jeopardise the impressive gains in the uptake of Further Mathematics, which are so much appreciated by universities.

Specific issues relating to A level reform that are especially important for Mathematics are:

1. **Modular structure**

A modular structure is the best structure for AS/A level Mathematics. A modular structure in mathematics

- can provide rigorous and searching assessment;
- provides the flexibility to allow students to select options and pathways appropriate to their aspirations and their intended further studies, with the potential to increase greatly the uptake of mathematics post-16;
- facilitates the provision of AS/A level Further Mathematics.

2. **The AS qualification**

It is important to retain AS qualifications in Mathematics.

- AS qualifications in Mathematics and Further Mathematics are valuable qualifications in their own right, helping to underpin the mathematics requirements of many other disciplines, including the social sciences as well as traditional sciences.
- AS mathematics qualifications can be taken by many more students than take A level, helping to increase participation in post-16 mathematics.

3. **The role of universities**

- Mathematics serves many university disciplines, so many university departments, not just mathematics, must be involved in developing A level Mathematics.
- Universities should be explicit about what mathematics qualifications are appropriate in preparation for different degree courses, including specifying which applied options are the most relevant.

4. **The impact on Further Mathematics**

- It is fundamentally important to ensure that the uptake in Further Mathematics does not fall as an unintended consequence of A level reform.

5. **Assessment**

- Developing valid assessment that has a positive impact on teaching and learning should be a major priority of curriculum development in A level Mathematics and must not be rushed.

6. **The role of employers**

- Progression to university is not the only purpose of A levels, and A level Mathematics is valued greatly by employers. The needs of employers should be considered explicitly as part of the development of A level Mathematics.

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Mathematics is enjoying a period of sustained growth in A level entries¹ and in recruitment to university Mathematics degree courses² and other degree courses where mathematics is a key component. Whilst changes should be made that improve current A level Mathematics specifications, great care is needed to avoid undoing recent gains.

A level reform presents an exciting opportunity to improve mathematics education. However, the Summer 2012 Ofqual A level reform consultation is problematic because it attempts to treat all subjects in the same way. The Curriculum 2000 experience provides ample evidence that changes that may be beneficial for some subjects can unintentionally be damaging for others.

Further Mathematics has lately shown stronger growth than any other mainstream subject, but there remains a great and urgent need to encourage considerably more learners to take the subject. It is already valued highly by many university mathematics departments, including at the most prestigious institutions, and is increasingly valued by other STEM departments and even by some outside the normal STEM area. Any changes to A level Mathematics must not prejudice Further Mathematics. Indeed, care should be taken to ensure that any such changes positively support learners who wish to take Further Mathematics in addition to Mathematics.

This paper attempts to highlight the major issues and opportunities for mathematics in relation to A level reform and to outline a way forward.

Specific issues relating to A level reform that are especially important for Mathematics are:

1. Modular structure
2. The AS qualification
3. The role of universities
4. The impact on Further Mathematics
5. Assessment
6. The role of employers

Each of these is discussed below, with conclusions and recommendations summarised in section 7.

¹ Between 2005 and 2012 A level Mathematics in England entries have increased from around 48 000 to around 76 500. The corresponding figures for Further Mathematics are from 5500 to 12 500 (source JCQ).

² Between 2005 and 2011 (most recent figures available), the number of students accepted onto mathematics degree courses has increased from around 5500 to around 7500. (see the 2012 [Institute of Physics report](#) for the accurate figures).

1. Modular Structure

It is worth noting that the large majority of university degree courses across all subjects are modular.

Paragraph 51 of the Ofqual consultation states: “*We propose that all future A level qualifications are no longer split into modules.*” A modular structure has very significant benefits for AS/A level Mathematics and Further Mathematics. MEI believes that a modular structure is the best structure for AS/A level Mathematics and Further Mathematics.

1.1 Meeting students’ needs

- 1.1.1 It is fundamentally important to recognise that AS/A level Mathematics is taken by students to serve a wide range of future aspirations. Only a small minority go on to read degrees in the mathematical sciences. The vast majority go on to use their mathematics to support study in almost every other discipline, ranging from the STEM subjects through medicine and the social sciences right through to the humanities. There are also, of course, learners who choose not to go straight to higher education at all, but to enter the world of work. A level Mathematics is faced with the difficult task of being fit for purpose for all such learners.
- 1.1.2 The different applied options within A level Mathematics and Further Mathematics allow students to make appropriate choices in line with their aspirations; potential social scientists can benefit from statistics options, whereas potential engineers or physicists can benefit from mechanics options, and potential business or computer science students can benefit from decision mathematics options.
- 1.1.3 A criticism of the current A level Mathematics is that ‘options’ are often determined by what the school/college is able to offer, rather than by individual student choices. However, this can be overcome; the work of the Further Mathematics Support Programme has shown that students can be supported very effectively to take applied mathematics options that their school or college is unable to provide directly.

1.2 Modularity and assessment

- 1.2.1 Concerns have been expressed that modular structure encourages superficial learning and a “teach-to-the-test” culture. MEI shares concerns about superficial learning and teaching-to-the-test, but believes that it is incorrect to attribute them to the modular structure in itself. Rather, the fault lies in overly predictable assessments with highly structured, near-standard questions that reward unthinking application of standard techniques. To the extent that this happens, it is a matter of failure of regulatory supervision of assessment, rather than a consequence of the modular structure. There is no reason why modular assessments cannot test mathematical ability in a more holistic way, in particular the ability to use mathematics creatively to solve worthwhile problems.
- 1.2.2 Modularity is also blamed for bringing about a culture of frequent assessments and re-sitting examinations to boost grades. However, modularity is about course structure and a well-designed modular course in mathematics emphasises links between topics and ensures modules link to and build upon one another in a coherent way. Mathematics is a naturally hierarchical subject and it is important for students to develop both a good knowledge and a lasting understanding of the earlier material, to build strong foundations for later work;

this is promoted by the material being examined in stages. If the modules are constructed well, then each is effectively synoptic, because mastery of earlier work is necessary in order for students to tackle new material. A modular course structure in mathematics need not encourage re-sits and need not be incompatible with terminal assessments.

1.3 *Helping to make Further Mathematics viable*

1.3.1 The applied mathematics options help schools and colleges to provide and timetable Mathematics and Further Mathematics efficiently. Further Mathematics serves to increase the breadth, as well as the depth, of students' knowledge, so several applied options can be included in either Mathematics or Further Mathematics qualifications. If a school or college offers, for example, four applied options to its A level Mathematics students (from which they must choose two), the Further Mathematics students can do all four, with two of them counting towards their Further Mathematics qualification. If this were not possible, it is likely that fewer schools and colleges would be able to offer Further Mathematics at all, which would reduce the number of students able to take it.

1.4 *Allowing flexibility to develop mathematics pathways for more level 3 mathematics students*

1.4.1 [In a speech at the Royal Society in June 2011](#), Michael Gove stated: *"I think we should set a new goal for the education system so that within a decade the vast majority of pupils are studying maths right through to the age of 18."*

1.4.2 Ofqual's international comparisons report asks: *"The number of different mathematics assessments at a variety of levels available to students in many education systems was also in contrast to A level Mathematics. Is there a need for A level Mathematics to have further lower-level options in addition to AS?"*

1.4.3 MEI believes strongly that there should be more mathematics options available for students who do not wish to take AS Mathematics. This can best be achieved through a modular system which enables transfer between pathways. This idea is expanded upon in MEI's recent discussion paper, ['How might A level Mathematics be improved?'](#).

2. The AS qualification

The Ofqual consultation on A level reform offered 3 options for the structure of A levels:

Option 1. Removing the AS qualification – which would mean a return to a linear two year course of study with all the assessment at the end of the course;

Option 2. Making the AS a standalone qualification but where the results do not contribute to the A level. This would mean the AS could be completed in one year but the A level would be a two year course of study and assessment as in option 1.

Option 3. Retaining the AS qualification and its relationship to the A level as at present but making changes to January assessments and resitting opportunities as outlined above;

MEI believes option 1 would be disastrous for mathematics. It is vital to retain AS qualifications in both Mathematics and Further Mathematics. They are important

qualifications that support students' progression to university and employment and there is considerable scope to increase their uptake.

Options 2 and 3 are not clearly defined, so no meaningful judgements can be made about them. Any proposed changes would require very careful consideration to assess what their negative consequences might be. A fair and unbiased consultation should also include a 'no change' option.

2.1 Meeting the needs of students

- 2.1.1 There is wide acceptance that there should be further increases in the uptake of A level Mathematics and Further Mathematics. Whilst most young people do indeed appreciate the value of taking mathematics beyond GCSE level, many consider mathematics to be a particularly difficult subject and are wary of committing themselves to a two-year A level course if they believe they are likely to achieve better grades from other subjects. The AS level enables students to 'try out' studying mathematics at this level, without preventing them from studying other subjects, and provides them with a worthwhile qualification should they choose not to go on to complete the A level.
- 2.1.2 Mathematics is a subject that continually builds on itself, requiring students to develop firm foundations in the first year of the A level course in order to succeed in the A2 examinations. Before AS levels were introduced, many students 'coasted' through the first year of the course, expecting to catch up in the second year. As a result many under-achieved or failed, effectively wasting two years of study.
- 2.1.3 AS level Mathematics and Further Mathematics are valuable qualifications in their own right and, with appropriate development, could be taken by far larger numbers of students than they are at present, contributing to Michael Gove's vision of far wider participation in mathematics post-16.

For many students who do not need to take the full A level Mathematics, AS Mathematics can be a very useful option, developing algebraic fluency and introducing basic calculus and statistical techniques that are important for a wide range of degree courses and careers, including economics and other social sciences.

As well as the direct utility that studying AS Mathematics provides, it also has significant general educational value. What knowledge is required for a person to be described as 'educated' in the modern world? As Michael Gove said in his [speech at the Royal Society in June 2011](#), "*it seems to me genuinely bizarre that in the 21st Century so many children leave school essentially trapped in a mathematical world predating Newton and Leibniz, essentially unaware of the development of calculus.*" Increased uptake of AS Mathematics by non-STEM students would help to address this issue.

AS Further Mathematics is valuable for students who wish to go on to degree courses with a strong mathematical content, such as in engineering or physics, but who do not expect to become 'mathematicians'. Studying for AS Further Mathematics increases students' mathematical confidence and fluency and introduces them to important new topics, such as complex numbers and matrices, which they will need on their degree courses.

2.1.4 Many students would benefit from studying AS Mathematics or Further Mathematics over two years, or in year 13. It is of great concern that proposed changes to post-16 funding arrangements seem likely to deter schools and colleges from offering these options.

2.2 Meeting the needs of universities

2.2.1 AS results are a vital source of information for universities. At the time when students are applying for university, AS results give an objective, up-to-date picture of their progress. Without them, universities would have to rely on GCSE scores. This would discriminate particularly against students from 11-16 schools, where accountability is focused on students achieving grade C, whereas many universities would seek students with A or A* grades. It is neither fair nor accurate to assess a student's suitability for a place on a degree course using the results of qualifications taken at age 15 or 16, more than two years before going to university. This is especially true for mathematics, where the demands and expectations of AS Mathematics are very different from GCSE.

2.2.2 University departments in disciplines with significant quantitative and statistical elements, such as biology, economics, geography, psychology and other social sciences, do not usually specify a requirement for students to study any mathematics beyond GCSE level. However, most academics in such disciplines believe that students who have not studied mathematics beyond GCSE level are at a serious disadvantage. AS Mathematics is a suitable qualification to prepare many students for the quantitative and statistical demands of such subject areas.

2.2.3 Many STEM departments in leading universities are now encouraging students to take AS Further Mathematics alongside A level Mathematics, recognising its value in preparing students for the mathematical demands of degree courses, particularly in subjects such as engineering and physics.

3. The role of universities

Paragraph 30 of the Ofqual consultation states: *"We want to adapt our regulatory approach to strengthen university involvement and to allow universities to determine subject content."*

When discussing the purpose of A levels, the Ofqual consultation suggests 'Condition 1' for awarding bodies should be to ensure that each A level qualification *"Defines and assesses achievement of the knowledge, skills and understanding which will be needed for Learners planning to progress to undergraduate study at a UK higher education institution, particularly (although not only) to study the subject concerned"*.

3.1 Meeting the needs of many different disciplines

3.1.1 Mathematics serves many university disciplines, so many university departments, not just mathematics, must be involved in developing A level Mathematics. Of the roughly 80 000 students who took A level Mathematics in 2011, fewer than 8000 went on to study Mathematics at university. Most of the other 90% went on to study other subjects, both STEM and non-STEM.

3.1.2 A level Mathematics is also valued greatly by employers, and they too should have a role in determining its content.

3.2 *Universities should specify appropriate mathematics qualifications in their offers*

3.2.1 Academics in many university disciplines express dissatisfaction at the mathematical knowledge and skills of undergraduates, yet universities often do not specify appropriate mathematics qualifications in their offers to students.

Offers should recommend or require AS or A level Mathematics or Further Mathematics wherever appropriate, and should also recommend or even require that students take particular applied options within these qualifications, relevant to specific degree courses, such as mechanics options for engineering and statistics options for social sciences.

3.2.2 However, the current struggle to fill places with well qualified “uncapped” students militates against providing clear advice lest some are deterred. This is no help to those choosing A level options. More thought should be given to the possible unintended consequences that university funding changes can have on pre-university education.

4. **The impact on Further Mathematics**

The dramatic growth in entries to AS and A level Further Mathematics in recent years has been a major success story. Universities, including many of the leading departments in mathematics, physics and engineering, are very appreciative of this. It is fundamentally important to ensure that the uptake in Further Mathematics does not fall as an unintended consequence of A level reform.

4.1 *The potential dangers to Further Mathematics*

4.1.1 The three major dangers to Further Mathematics are:

(a) The removal of a modular structure allowing applied options that facilitate the teaching of AS/A level Further Mathematics alongside A level Mathematics, as discussed in 1.3.1.

(b) The removal of AS level, which is so valuable in Further Mathematics to support students progressing to STEM degrees, as discussed in 2.1.3.

(c) Changes to post-16 funding arrangements that do not provide appropriate funding for larger programmes.

5. **Assessment**

Paragraph 60 of the Ofqual consultation states: *“It is important that assessment in each subject is valid and supports good teaching and learning.”*

5.1 *Improving the validity of assessment in A level Mathematics*

5.1.1 MEI agrees that a key to improving A level Mathematics is to improve the validity of the assessment, to ensure that what is assessed aligns with the knowledge and skills we want students to develop in mathematics.

5.1.2 The high-stakes nature of examinations, for students and for their schools and colleges, combined with overly structured and predictable assessments (as discussed in 1.2.1 and 1.2.2), can all too easily lead to a “teach-to-the-test” culture, which has a negative influence on teaching and learning in mathematics. There will always be an element of “teaching-to-the-test”. The challenge for curriculum development is to develop tests worth teaching to.

- 5.1.3 Universities and employers commonly express concern that students with good grades in A level Mathematics have poor mathematical modelling and problem-solving skills and are unable to apply the mathematics they have learned at A level to solve meaningful problems. These are difficult skills, which students have always found hard to master. Work is needed to develop better assessments that measure the development these skills.

5.2 *Challenging the most able*

- 5.2.1 Students currently achieve an A* in A level Mathematics by scoring very highly on standard questions, i.e. for not making careless mistakes, rather than for demonstrating real mathematical flair. The A* grade in mathematics, as currently awarded, is not fit for purpose. However, an A* grade that identifies real mathematical ability certainly is needed. It would be far better to identify mathematically gifted students in some other way, which would test their ability to answer questions with less structural scaffolding and allow them to demonstrate creative mathematical problem solving skills.
- 5.2.2 Assessing A* in a more appropriate way would also highlight the value of high-level mathematical problem solving skills to students, and encourage teachers to foster these skills among our best future mathematicians, scientists and engineers.

5.3 *The danger of rushing A level reform*

- 5.3.1 New assessments should be developed that can have a positive effect on teaching and learning in Mathematics. Possible approaches are outlined in MEI's recent discussion paper, [*'How might A level Mathematics be improved?'*](#).
- 5.3.2 The development of improved assessment takes time. Serious research and trialling are required. This must not be rushed. A level reforms in mathematics should not be introduced before this work has been done. The prize of getting this right would be more than worth the wait.

6. **The role of employers**

Section 3 has already highlighted paragraph 30 of the Ofqual consultation, which states: *"We want to adapt our regulatory approach to strengthen university involvement and to allow universities to determine subject content."*

Though Ofqual has consulted with employers to find out their views about A levels, it is noticeable that the consultation makes no mention about employers' involvement in helping to determine subject content.

6.1 *Meeting employers' needs*

- 6.1.1 Progression to university is not the only purpose of A levels, and A level Mathematics is valued greatly by employers. The needs of employers should be considered as part of the development of A level Mathematics.
- 6.1.2 MEI welcomes Ofqual's requirement on examination awarding bodies to work with *'employers and/or employer groups, where appropriate, so that they can consider whether A levels can meet their particular requirements.'*

7. Conclusions and recommendations

- 7.1 Reforming A level Mathematics and Further Mathematics is an exciting opportunity, and MEI wishes to be in the forefront of this work. However, great care must be taken to avoid jeopardising significant increases in the uptake of AS/A level Mathematics and Further Mathematics.
- 7.2 Mathematics at this level serves many different purposes, and the flexibility offered by a modular structure is vital. For this reason MEI supports strongly the retention of a modular structure for AS/A level Mathematics and Further Mathematics.
- 7.3 AS levels in Mathematics and Further Mathematics must be retained. They are valuable qualifications in their own right and there is considerable room for increased uptake.
- 7.4 A level Mathematics is a key subject for supporting many different university degree disciplines and careers, so university academics from a variety of backgrounds and employers' representatives should be involved in development work in A level Mathematics.
- 7.5 To improve students' mathematical preparation for university degrees, university departments should be explicit in their offers about which mathematics qualifications students should study to support their degree courses, including which applied mathematics options they should choose.
- 7.6 Changes to both post-16 funding and university funding can influence the uptake of AS/A level subjects. AS/A level Mathematics and Further Mathematics are particularly vulnerable to this because both are considered demanding and because Further Mathematics is almost always taken as part of a large A level programme of four or more subjects. Appropriate measures should be taken to ensure funding changes do not have a negative effect on the uptake of AS/A level Mathematics or Further Mathematics.
- 7.7 The large increases in the uptake of AS and A level Mathematics and the dramatic increases in the uptake of AS and A level Further Mathematics have been major successes in recent years. No changes should be made that could jeopardise these increases.
- 7.8 Developing valid assessment that has a positive impact on teaching and learning should be a major priority of curriculum development in AS/A level Mathematics.
- 7.9 The A* grade in A level Mathematics should be assessed in a more appropriate way, to encourage students to develop the creative mathematical problem-solving skills that are so highly prized by universities and employers.
- 7.10 The needs of employers should be considered explicitly as part of the development of A level Mathematics.
- 7.11 It is vital that A level reform is not rushed. If appropriate time is taken to develop and consult on new specifications, including use of different types of assessment, significant improvements can be made to AS/A level Mathematics and Further Mathematics that will have lasting benefits for education and the economy.