# How might A Level Mathematics be improved?
# An MEI discussion paper, June 2012

## Introduction

Recent reports from ACME (*Mathematical Needs, 2011*)[1] and the Nuffield Foundation (*Is the UK an Outlier?, 2010*)[2] indicate that there is a need for far greater participation in mathematics education post-16 if we are to compete effectively in the global economy, and this message has been reinforced strongly by government:

"*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.*"

Michael Gove, Secretary of State for Education, July 2011

A level Mathematics reform, alongside the development of new level 3 pathways in mathematics, offers a major opportunity to improve mathematics education post-16 and to raise participation in post-16 mathematics to a level comparable to that of our international competitors.

Talking to teachers and university lecturers, and noting the increased uptake of A level Mathematics and Further Mathematics (see appendix 1), leads MEI to believe that the current Mathematics A levels have both strengths and weaknesses. This short paper attempts to summarise these strengths and weaknesses and discusses other factors that influence the uptake of A level Mathematics. It also outlines some ideas for how A level Mathematics and related level 3 mathematics qualifications might be developed to better meet the needs of students, higher education and employers.

The DfE has indicated that there will be a consultation on A level reform this summer and MEI welcomes this. However, the present paper also makes a plea for caution. Things of moment ought to be done with due deliberation and these reforms must not be rushed. At best this could result in a missed opportunity to make significant improvements to the nation's mathematics education; at worst it could result in serious damage, as occurred following the Curriculum 2000 reforms, when the number of students taking A level Mathematics fell by more than 20%.

Innovators in Mathematics Education

## 1. What are the strengths of the current A level Mathematics and Further Mathematics?

(a) There seems to be a general consensus from university departments specifying A level Mathematics in their offers that the overall content is basically correct, though there may be some discussion about the details.

(b) Uptake is increasing rapidly in both A level Mathematics and A level Further Mathematics (see appendix 1). Changes that could jeopardise uptake should be avoided.

(c) There is a substantial common core of pure mathematics content in all A level Mathematics specifications, and Further Mathematics specifications also have a considerable amount of pure mathematics content in common. However, the modular structure allows some choice of applied units, which can enable students to choose options appropriate to their future aspirations – this is especially the case for students who study both Mathematics and Further Mathematics.

(d) The assessment of AS level at the end of year 12 helps to ensure that students are motivated to work hard in the first year of a two-year A level course and gives a valuable indication of progress and potential, which is useful to students, teachers and universities.

## 2. What are the weaknesses of the current A level Mathematics and Further Mathematics?

(a) No suitable level 3 mathematics/statistics course exists for students who have a grade C or above in GCSE Mathematics but whose aspirations mean they do not wish to study AS/A level Mathematics.

'*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?*' (Ofqual, May 2012)[3]

(b) Examination questions can often be highly structured and predictable, which can lead to an instrumental 'learn the rules' approach to teaching and learning. This discourages deep understanding and misrepresents mathematics as a boring subject to be learned by rote. Most seriously, this approach inhibits the development of the mathematical thinking and problem solving skills that are highly valued by universities and employers.

(c) Linked to (b), a 'teach-to-the-test' culture has developed. While this is understandable, up to a point, due to the very high stakes nature of the examinations, it has become common, at least in some schools and colleges, for students to be trained to answer examination questions, rather than educated to develop the powerful, transferable mathematical skills needed for higher education and employment.

(d) The current A level Mathematics specifications are not adequately regulated, so the full requirements and intentions of the GCE Mathematics subject criteria[4] are often not properly met; this has exacerbated the 'teach-to-the-test' culture.

For example, part of the current assessment objective AO4, *'..read critically and comprehend longer mathematical arguments or examples of applications'*, is rarely assessed by most specifications.

(e) The current modular structure, particularly the way in which scores on AS units contribute to the overall A level grade, encourages tactical re-sitting, which artificially raises grades and wastes resources.

(f) A level Mathematics grades fail to discriminate effectively between the more able students, which means it is difficult for universities to identify the most mathematically able. In 2011, 44.8% of A level Mathematics students achieved a grade A or A*. (JCQ, 2011)[5]

(g) The A* grade, awarded for scoring highly on standard examination papers, rewards accuracy rather than mathematical flair and can fail to identify many of the most mathematically able.

(h) In many cases, particularly where there are small numbers of students, the 'choice' offered by the different applied options is determined by what teachers or schools/colleges are able to offer on the timetable, rather than being tailored to the needs or interests of students.

(i) Students with a grade C (and to a lesser extent those with a grade B) in GCSE Mathematics, are unlikely to succeed at AS/A level Mathematics[6]. Such students need further reinforcement of GCSE level mathematics before they can progress to AS Mathematics, but there are few suitable courses and uptake is very low.

(j) There is little integration of the use of computer technology into teaching, learning or assessment, even though computer technology has revolutionised the application of mathematics and statistics in higher education and industry.

Innovators in Mathematics Education

## 3. What would improve A level Mathematics and Further Mathematics?

(a) A greater variety of assessment instruments should be used to increase the overall validity. This might incorporate different forms of assessment, the better to assess problem-solving skills and motivate improvements in teaching and learning.

*'The quality of a qualification can be measured in various ways and for us the key measure is validity – that is, the extent to which the qualification gives a true measure of learning..'*

*'Our aims will be to promote coherence – for example between the syllabus, teaching and testing – and to increase validity.'* (Ofqual, 2012)[7]

(b) The relative weighting of AS units compared to A2 units could be reduced, or AS and A2 could be decoupled. This would place more emphasis on the A2 units when calculating the overall A level grade. However, many other facets of the overall grading system would need to be considered too, and much detailed thought would need to be given to any such change of weighting.

(c) A level grades should both reflect students' achievement and enable universities and employers to differentiate effectively between them. This is a very complex issue, requiring careful consideration across all subjects. It is important to ensure that A levels in some subjects are not 'easier' than others; this could affect uptake.

(d) All A level Mathematics specifications and assessment regimes must be required to honour the full requirements and intentions of the GCE Mathematics subject criteria[4]. However, the regulatory framework must not inhibit, and should encourage, well-founded curriculum development and innovation, otherwise there is a danger of stagnation.

(e) The A* grade should be awarded on a separate paper with an emphasis on testing mathematical problem solving skills, rather than the accurate application of standard techniques to standard, structured questions.

(f) The increasing need for more people to understand and use more mathematics and statistics in higher education and employment means that the current GCE Mathematics subject criteria[4] should be reviewed to ensure they are still appropriate.

(g) AS Mathematics should be considered a worthwhile course in its own right and far more students should be encouraged to take it, with many taking it over two years. Funding arrangements should be amended to facilitate this.

(h) Students with grade C at GCSE, whose aspirations mean they would benefit from taking AS Mathematics over two years, should be encouraged to take a suitable bridging course. An example of such a bridging course is OCR's Foundations of Advanced Mathematics level 2 Free Standing Mathematics Qualification[8] (FSMQ), but this would need some development and we would expect new provision to become available too.

(i) Clear level 3 mathematical pathways should be available for all students who have achieved grade C or above in GCSE Mathematics. Possible pathways are suggested in ACME's 'Post-16 in 2016'[9] paper and MEI's 'Mathematics for all post-16'[10] position paper.

(j) The structure of post-16 level 3 mathematics qualifications should be reformed to introduce a new mathematics/statistics qualification suitable for all students with a grade C or above in GCSE Mathematics, building on the experience of qualifications such as AQA's level 3 FSMQs[11]. (see appendix 2)

## 4. Related factors that affect participation in A level and other Post-16 Mathematics

(a) Students' decisions to choose A Level Mathematics are influenced by a number of factors, including their experiences at GCSE. Improving students' experience of GCSE Mathematics is essential in order to further increase participation in A Level Mathematics.

(b) Early entry to GCSE Mathematics is likely to have a negative effect on progression and should be strongly discouraged.

*'For pupils who achieve level 4 or above at KS2 (and would therefore be expected to achieve grade A*-C at GCSE) the average final grade is lower for early entrants. Higher attaining pupils are therefore being disadvantaged by entering early and not achieving their full potential.'* (DfE, 2011)[12]

(c) The number of girls taking A Level Mathematics and Further Mathematics is significantly lower than the number of boys. This limits girls' progression into Higher Education and careers in STEM.

*'… by GCSE [in mathematics], there is no gender difference at grades A*/A. The gender difference at AS/A level relates to participation, with the ratio of boys to girls being around 3:2 for mathematics in 2011 and roughly twice as many boys as girls took further mathematics.' (*Ofsted, 2012)[13]

For girls, enjoyment of GCSE Mathematics is a very significant factor in choosing to study A level Mathematics.

*'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.'* (QCA, 2007)[14]

(d) Guidance for students at Key Stage 4 on their subject choices post-16 must be improved, to ensure that students understand the importance of mathematics for progression into higher education and employment.

*'We estimate that of those entering higher education in any year, some 330,000 would benefit from recent experience of studying some mathematics (including statistics) at a level beyond GCSE, but fewer than 125,000 have done so.'* (ACME, 2011)[1]

*'Employers emphasized the importance of people having studied mathematics at a higher level than they will actually use. That provides them with the confidence and versatility to use mathematics in the many unfamiliar situations that occur at work.'* (ACME, 2011)[1]

## 5. Next Steps

(a) The A level Mathematics criteria should be reviewed and revised accordingly, to ensure they are still fit for purpose. Specifications should be required to adhere to all aspects of the overall regulatory framework, but this framework must itself be flexible enough to allow innovation.

(b) New specifications should be developed against the revised criteria and properly trialled in schools and colleges.

(c) As part of the development of new specifications, new modes of assessment should be developed and trialled with schools and colleges. These could include consideration of a variety of elements such as coursework, multiple choice, use of pre-release material, comprehension, more questions with less structure and a teacher-assessed portfolio.

(d) Alongside the development of new A level Mathematics and Further Mathematics specifications, new level 3 mathematics/statistics qualifications should be developed and trialled to ensure coherent mathematical pathways for students with grade C or above in GCSE Mathematics whose aspirations mean they do not wish to study AS/A level Mathematics. Such students should be able transfer to AS Mathematics and beyond should their aspirations change.
(See appendix 2)

(e) Alongside the development of new A level Mathematics and Further Mathematics specifications, a new bridging course should be developed for students with grades C or B in GCSE Mathematics to develop their mathematics skills to a level where they can make an effective transition to AS level Mathematics and beyond. (See appendix 2)

(f) Alongside the development of new A level Mathematics and Further Mathematics specifications, a new A* paper should be developed to help universities to identify the most mathematically able students.

(g) Careful consideration should be given to reducing the relative weighting of AS units compared to A2 units, or to decoupling AS and A2 (this should apply across all A level subjects).

(h) There should be a wide-ranging study of awarding procedures, with a view to developing an A level awarding system across all subjects that appropriately recognises achievement, whilst also enabling universities and employers to differentiate effectively between students.

(i) MEI strongly favours the Linked Pair GCSE (MLP); this has the potential to increase student enjoyment of and engagement with mathematics and so increase participation levels beyond GCSE, especially for girls.

'*Centres offering both the MLP and the new single GCSE found MLP students to be more engaged with and committed to mathematics than those doing the single GCSE. The applications of mathematics, and financial applications in particular, were cited as the main reason for enhanced student engagement with, commitment to and understanding of mathematics.*' (DfE, 2012)[15]

*'The present system for GCSE Mathematics, based on a single award, is not fit for purpose and should be replaced by one offering two GCSEs as soon as possible.'* (Mathematics Task Force, 2011)[16]

The Linked Pair GCSE should replace the single GCSE Mathematics.

Mathematics is a key facilitating subject. If the A level Mathematics reforms are not effective, the whole A level reform process will be undermined. It is vital that reforms are not rushed, so that appropriate trialing can take place.

## References


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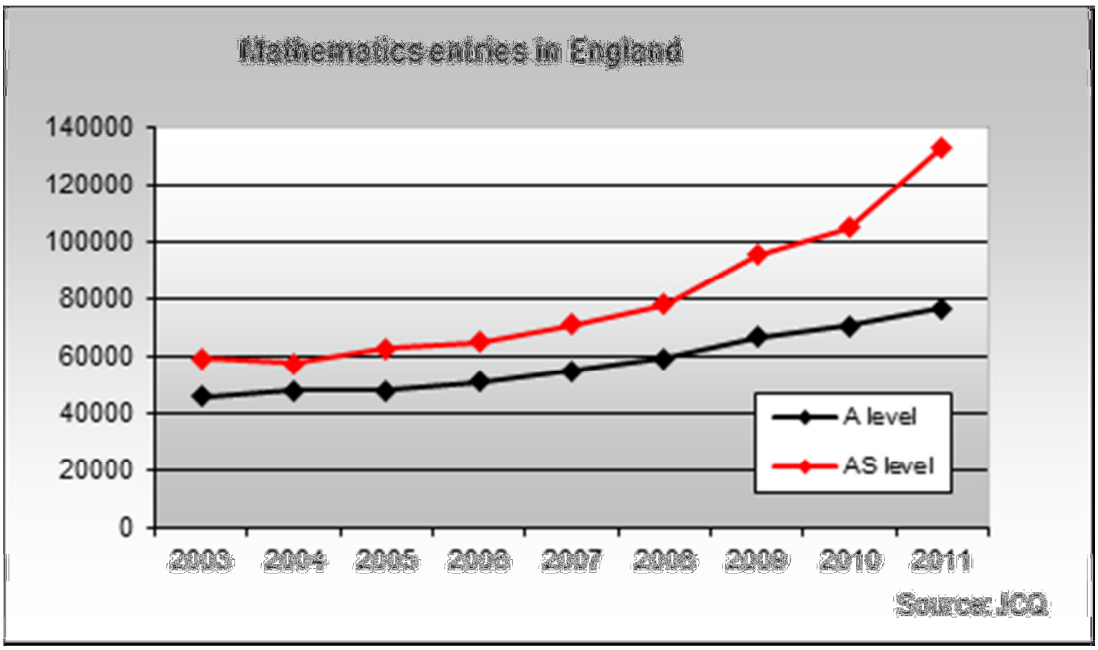
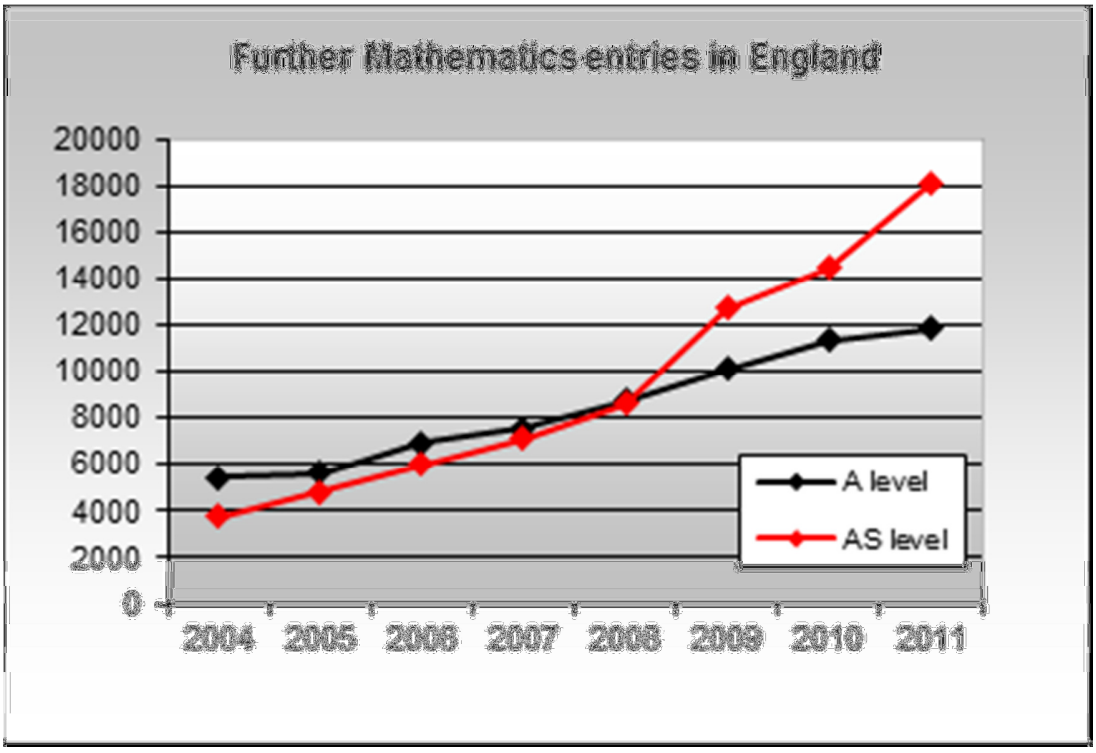
Appendix 1

**Recent increases in A level Mathematics and Further Mathematics**



Appendix 2

**Possible outline structure of post-16 Mathematics at level 3**