Nuffield Foundation response to the Department for Education Survey on the DfE Policy Statement on 16 to 18 Core Maths Qualifications

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4. What is your view on the proposed characteristics of core maths qualifications that will count towards the level three maths 16-19 accountability measure?

	Satisfied	Satisfied with minor amendments	No view	Not satisfied
Size		✓		
Content				✓
Grading	✓			
External Assessment				✓
Synoptic Assessment				✓
Assessment Objectives		✓		

5. Please tell us why you have selected your answers to the previous question about the characteristics of core maths qualifications.

We welcome the government's recognition of the importance of increased participation in post-16 mathematics and the need to develop a new qualification route to complement AS and A level Mathematics. There are significant strengths to the proposals for Core Mathematics and it is clear that attention has been paid to the views of the mathematics education community and to other beneficiaries of improved mathematics education. It is vital that the qualification is seen by all stakeholders as high status. But it is also important that it is not seen as an alternative to A level or AS Mathematics for those who would benefit from these existing qualifications and are able and willing to take them. Welcome as the qualification is, it will need further sustained attention if we are truly to make a step-change in the numeracy of our students.

Size (and duration)

The increase in the size of the qualification to around 'half of an A level' feels right for most students. One third would not have given the qualification enough weight to have serious currency with higher education institutions and to garner recognition by employers.

The expectation that Core Mathematics would run over the full two years is important. The ACME *Mathematical Needs* study [1], which surveyed a range of employers and higher education institutions and courses, found that 'it is not just a case of students missing out on two years of learning mathematics, serious though that is, but of their arriving at the next stage of their lives having forgotten much of what they did know'. But rather than simply ensure that every Core Mathematics qualification runs over two years, it would make sense to have a two-year 'pathway' but with modules that allow students to join for shorter periods. This flexibility is particularly necessary to accommodate the substantial number of students who could be sitting or re-sitting GCSE Mathematics in Year 12 and then achieving a grade C or better at the end of that year. Continued engagement with mathematics after GCSE is essential both for this group of students as well as those who achieve a good grade at the end of Year 11. A possible means of achieving this is through a suite of connected components, as is the case with the *Use of Mathematics* Free Standing Mathematics Qualifications (FSMQs). Such a model might also allow for variability in size, ranging from a third of an A level to half an A level. This would accommodate the needs of those students who do not achieve a good GCSE grade until Year 12 and who therefore would not have the time to undertake the equivalent of half an A level in Year 13. Furthermore, this model could allow one of the components to be about project work, where students apply the mathematics they have learned to a topic or issue that interests them. The FSMQs and International Baccalaureate include such project work.

Content

The general statements spelling out the focus of Core Mathematics content are sensible, although it seems that the terms 'approaches', 'processes' and 'practices' might be more appropriate than 'content'. All three bullet points are strongly related to mathematical modelling, and the focus on modelling and related processes could be fleshed out. Indeed, the ACME *Mathematical Needs* [1] report found that 'the development and subsequent application of mathematical models in the workplace is pervasive, and an early exposure to the modelling process in mathematical learning is essential'.

It will be important to ensure that Core Mathematics uses and builds on the content of the new GCSE Mathematics, as the precise nature of that content becomes clear.

The use of calculus is suggested as optional and challenging material. Given that Core Mathematics is to cater for a wide range of students (for example social science, humanities, and business students), our view is that statistics would be far more relevant than calculus. The ACME *Mathematical Needs* [1] report recommended that 'the new post-16 courses should include statistics beyond the descriptive methods of GCSE to meet the needs of the large number of students who progress to a range of courses such as those in social and life sciences'. It also noted that 'individuals are often underprepared mathematically for the statistics/quantitative methods components of degrees in social and biological sciences' and 'statistics provision post-16 should include inference, experimental design, probability, risk and the use of statistics to aid decision-making'. We share this view and believe that a good understanding of these areas is vital for a range of disciplines that might be studied in conjunction with the new qualification (at A level) or later (at university), including social sciences and biology.

Reinforcing the above points, the Nuffield Foundation report *Towards universal participation in post-16 mathematics* [2] looked at post-16 mathematics in a number of high-performing jurisdictions, including Hong Kong, Massachusetts and Singapore, and found that 'in New Zealand, the widespread availability of a well-respected option focused on mathematical fluency, statistics and the application of mathematics appears to have increased participation in advanced mathematics' and that 'for many disciplines in higher education, mathematical fluency is more important than knowledge of calculus'. We also think it is important that the focus of the content, resources and teaching of the qualification includes using mathematics and statistics in the context of real world examples from a range of areas including from the social sciences.

Finally, challenge is not simply a function of content but of a range of inputs such as context and exemplification, depth of engagement, assessment and so forth. The content section could therefore expand on the type and complexity of mathematical skills and experiences students should have. Studies conducted by SCORE, *Mathematics within A-level science 2010 examinations* [3] and by the Nuffield Foundation, *Mathematics in A level assessments: A report on the mathematical content of A level assessments in Business Studies, Computing, Economics, Geography, Psychology and Sociology* [4] used a research-informed framework to analyse the extent, type and complexity of the mathematics within a range of subject assessments. Such a framework could inform the content description and the assessment of Core Mathematics.

Grading

A Fail, Pass, Merit, Distinction scale would be worth exploring, especially in the presence of significant internal assessment and/or project work. Employers and universities are likely to take the qualification more seriously if it has this sort of marking scale. Significant work would be needed to determine minimum benchmarks for the scale, and much could be learned from the experience of the *Extended Project Qualification* (EPQ). Again, universities and employers would need to be consulted and informed fully about such a scale. This would need to highlight the course content and approach and the benefits of student engagement with such courses. A robust marking of general competence as above would not be able to help universities and employers to reach fine-grained conclusions on students' mathematical skills and knowledge. But it would help engender greater confidence in the skills being taught, and motivate students.

External Assessment

We believe that the minimum 80% external assessment is unhelpful, especially if the large majority of external assessment is required to be based on examination. While it is important that there is high confidence in Core Mathematics qualifications, that is not simply a function of external assessment. The EPQ has been growing significantly in numbers and is increasingly valued by higher education institutions and employers. It is an internally assessed (and moderated) qualification, and its grading scale is readily aligned with Fail, Pass, Merit, or Distinction.

Synoptic assessment

Including synoptic assessment would be helpful, though it does not have to be undertaken in an examination setting. Project work can provide an excellent opportunity for students to make links between different areas of mathematics and apply the skills, knowledge and understanding that they have developed.

Assessment Objectives

The listed assessment objects are highly relevant and should be implemented. Significant work will need to be undertaken on the monitoring and moderation of assessment to ensure that awarding organisations deliver on the promise of these qualifications. The earlier referenced SCORE and Nuffield Foundation work [3, 4] on mathematics in science and social science A levels could inform such monitoring.

6. What is your view on other considerations for core maths qualifications?

	Satisfied	Satisfied with minor amendments	No view	Not satisfied
Technology				✓
University and Employer role				✓

7. Please tell us why you have selected your answers to the previous question about other considerations.

Technology

It is unfortunate that the use of appropriate technology is not being embraced more strongly, let alone listed as a requirement. The ACME *Mathematical Needs* [1] report highlighted that 'students need to experience the power of computer software when applied to problems that can be formulated mathematically'. Many of the topics of interest for Core Mathematics students (e.g. the use of quantitative methods in social sciences, working with big data, mathematical modelling) are best handled using technology. Indeed, that can permit a deeper understanding as it helps especially with inductive reasoning, which may be particularly important for statistical skills. Further, relevant software, including free software such as R or commercial software such as MATLAB or SAS, is now readily available and accessible for sixth form students. This can be seen from the SAS Programming for High School curriculum in the US http://support.sas.com/learn/ap/hs/index.html and the experience of Year 12 students who engage on summer Nuffield Research Placements www.nuffieldfoundation.org/nrp. There are also a range of other relevant computer-based statistics education tools such as those available at http://understandinguncertainty.org/view/animations.

University and Employer Role

Much of the longer term success of this qualification will depend on a process of social change. It is vital that the government (both DfE and BIS) works closely over a period of time with both the higher education sector and employer organisations to ensure that they engage with the content of the qualification and develop some degree of confidence in it. It will be critical that universities and employers not only recognise the qualification as an indicator of an area of skill and understanding, but also *ask* for the qualification and signal to schools and students that they look favourably on it. Input from academics and employers will therefore be essential. But the current timeline will only allow for superficial engagement, despite the DfE setting 'a requirement for evidence to be provided by awarding organisations that qualifications have been designed with input from university academics and employers'. The recent success of the EPQ is interesting in this context.

There is some strong international evidence about this issue. The Nuffield Foundation report *Towards universal participation in post-16 mathematics* [2] observed that 'the experience of Hong Kong, New Zealand and Singapore indicates that the strongest incentive for students to study advanced mathematics is that they are required to do so to progress to higher education and employment'.

For instance, we believe that our own 'Q-Step' programme in the social sciences in higher education could be helpful in encouraging university departments of social sciences to seek students who have had continuing mathematical and statistical engagement post-GCSE. But that programme will take five years to bear fruit. It will be important for government to spend at least as long encouraging and 'nudging' HEIs and employers to engage with the developing content of the curriculum, to work with schools to send a clear message that they value the qualification, and increasingly to use it in their selection processes (which will in turn encourage schools and students to take the qualification to heart).

8. What is your view on the outline timetable for the introduction and teaching of core maths qualifications?

Satisfied	Satisfied with minor amendments	No view	Not satisfied
			✓

9. Please tell us why you have selected your answer to the previous question about the timetable for the introduction and teaching of core maths qualifications.

The timeline is extremely rushed in the Design and Development phase (effectively March – July 2014). There is strong evidence that qualifications that are not developed carefully tend to fall by the wayside. Related to this, more attention needs to be given to the lessons from existing provision such as the EPQ, FSMQs, IB, and Statistics A level. The Nuffield Foundation report *Towards universal participation in post-16 mathematics* [2] found that for jurisdictions with high participation rates in post-16 mathematics, 'key features appear to be longer timelines for the development and implementation of policy, and inclusive approaches to policy-making'.

The use of 'early adopter schools' is a potentially good way of exploring the use and impact of Core Mathematics. But a clear process of trialling, evaluation and research into early introduction will be needed, and we should welcome the development and improvements that such an iterative process would allow. This could well be part of the role and remit of the Core Mathematics Support Programme, but the expectations for such a longer-term programme should be clarified at the outset.

10. What else should the Department for Education take into account when developing technical guidance for awarding organisations on core maths qualifications for inclusion in 16-19 accountability tables? (Optional)

The Nuffield Foundation report *Towards universal participation in post-16 mathematics* [2] included the following recommendations:

Recommendation 14: The success of any new qualification will be dependent on ensuring it is widely available and supported by appropriately designed performance measures. Strong incentives should be provided for schools and colleges to offer all advanced mathematics options.

Recommendation 16: Research, including modelling scenarios, is necessary to understand how many more mathematics teachers are needed, the extent to which existing teachers can be retrained, whether former teachers can be attracted back, and how any potential negative effects on lower secondary or existing advanced mathematics routes can be avoided.

We commend the government's drive on the first of these recommendations, but much more needs to be done to address Recommendation 16. We acknowledge that there is a chicken and egg problem: the fact that there are unlikely to be enough secondary teachers who can cover the skills confidently is a symptom of the long-term problem that the new qualification is attempting to solve. But there is no doubt that the pool of appropriate teaching skills and capacity will be stretched by the introduction of Core Mathematics if it is successful. Active help from government may well be needed to develop the appropriate teaching cadre. Nuffield is starting to explore the scale of the problem, including in the Further Education sector where the evidence base is particularly weak. Findings will not be available until later in the year. Related findings would also inform CPD provision for Core Mathematics teachers, which is a critical need. We do not think this shortfall in teachers is a reason to delay introduction of the qualification. But we think that it will take some years of active work to build up the work-force and government will be an important player in ensuring that initiatives and incentives that address this issue in the longer term are driven forward.

[1] *Mathematical Needs (Theme A): Mathematics in the workplace and in Higher Education*
www.acme-uk.org/media/7624/acme_theme_a_final%20(2).pdf

[2] *Towards universal participation in post-16 mathematics: lessons from high-performing countries*
www.nuffieldfoundation.org/sites/default/files/files/Towards_universal_participation_in_post_16_maths_v_FINAL.pdf

[3] *Mathematics within A-level science 2010 examinations*
www.score-education.org/media/10036/full%20maths.pdf

[4] *Mathematics in A level assessments: A report on the mathematical content of A level assessments in Business Studies, Computing, Economics, Geography, Psychology and Sociology*
www.nuffieldfoundation.org/sites/default/files/files/Maths_in_A_level_Assessments_Nuffield_Foundation_WEB.pdf