ROYAL STATISTICAL SOCIETY

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Royal Statistical Society remarks to the independent review of post-16 mathematics led by Professor Sir Adrian Smith

The government announced in the March 2016 budget that Professor Sir Adrian Smith will "review the case for how to improve the study of maths from 16 to 18, to ensure the future workforce is skilled and competitive, including looking at the case and feasibility for more or all students continuing to study maths to 18, in the longer-term. The review will report during 2016." The stated focus is "to review the potential for improving the nature and scale of the study of mathematics from 16 to 18 to ensure that the future workforce has the appropriate mathematical and quantitative skills."

One of the RSS's key strategic goals is for society to be more statistically literate, so that people's understanding of data, risk and probability can inform their daily decision making, leading to better outcomes. Our data manifesto highlights the need to train teachers from primary school through to university lecturers to encourage data literacy in young people from an early age.

Our starting position, applicable across all study pathways, is therefore that

- **Everyone needs to be able to use and interpret statistical information**, to benefit their studies (regardless of subject), their everyday lives, their engagement in the democratic process, and their future careers.
- **Statistics is both a process and a way of thinking** – both must be taught and understood by students and teachers.
- **Statistics and data handling are integral to an increasing number of curriculum subjects, and are rooted in the mathematical sciences**. Statistics is an important area of study within the mathematical sciences and is also a crucial tool for a wide range of subjects that involve data, now or in the future.
- **Students must learn the whole statistics cycle** – analysing the problem, gathering, assessing and analysing data, and interpreting the results in the context of the original problem.
- **Students must be taught statistics in realistic, modern contexts** – including the use of realistic data analysed using ICT. This will ensure that what is being taught is relevant and appropriate for the future – avoiding routine calculation, handling realistic data sets, using appropriate software.

Remarks to questions circulated from the Review team

Q. What is your view of the post-16 maths pathways/qualifications currently available to students? And 4. What more can be done to improve student achievement in post-16 maths where it's offered? (of all kinds) and a question from the HoDoMS list: What basic level of mathematics and quantitative skills do businesses and higher education need school leavers to possess? Do leavers meet those levels now?

We have three key points, as follows:

- There is a need for all pathways to support progression to higher levels, and to support growth of statistical and data skills.

In an increasingly data rich world, there is a growing consensus that young people should leave school or college able to understand, analyse and critique data in their lives: as learners, as employees and as citizens.[1,2,3] Many jobs now require problem-solving skills and greater competence and confidence in using data, and among recent graduates a degree in mathematics confers a relative advantage.[4,5] A shortage of talent for data analytics in the UK has been identified in surveys and reported by many stakeholders in industry, and demand is driven in part by the increasing availability of big data for analysis in all sectors of the economy. [6]

- The gap in mathematics participation between compulsory mathematics at Level 1 and 2 (GCSE), and A Level Mathematics and Further Mathematics at Level 3, needs to be addressed. We need a range of qualifications to bridge this gap as a singular mathematics pathway will not meet all needs.

[1] Prime Minister's Office (2014) 'Maths and science must be the top priority in our schools, says Prime Minister' (online), 8 December 2014. Available at: https://www.gov.uk/government/news/maths-and-science-must-be-the-top-priority-in-our-schools-says-prime-minister

[2] British Academy (2012) 'Society Counts' (webpage), available at: http://www.britac.ac.uk/policy/Society_Counts.cfm

[3] British Academy (2015). *Count us in, quantitative skills for a new generation* (PDF). Available from: https://gss.civilservice.gov.uk/wp-content/uploads/2015/08/Count-Us-In-Full-Report.pdf

[4] Advisory Committee on Mathematics Education (ACME) (2011) Mathematical Needs: Mathematics in the workplace and in Higher Education (PDF). Available from: http://www.acme-uk.org/media/7624/acme_theme_a_final%20%282%29.pdf

[5] De Vries, R. (2014) Earning by Degrees: Differences in the career outcomes of UK graduates (PDF). Sutton Trust. Available from: http://www.suttontrust.com/wp-content/uploads/2014/12/Earnings-by-Degrees-REPORT.pdf

[6] See e.g. Bakhshi, H. Mateos-Garcia, J. & Whitby, A. (2014) *Model workers: how leading companies are recruiting and managing their data talent* (PDF). Nesta, UKCES, Royal Statistical Society, Creative Skillset. Available from: http://www.nesta.org.uk/sites/default/files/model_workers_web_2.pdf

Bridging the gap will in our view require more flexibility from government conditions of funding for English and maths, which makes re-sits of GCSE mathematics mandatory for students attaining below a Grade 4 benchmark. [7] There has been a modest growth in pass rates by this, however we believe that students should not be pushed to re-sit if this is unproductive. Students who came close to a Grade 4 or 5 at GCSE and who are capable of pursuing Level 3 study are likely to be demotivated, whereas those with the lowest grades are likely to get stuck. The government intends to revise the benchmark standard upwards to Grade 5 for students who start their course in 2020, and we have heard substantial concerns that this will make the number of re-sits unmanageable. [8]

We envisage alternative qualification routes that might be more successful at raising skills. For example, Functional Skills (which spans Level 1 and Level 2) might lead to GCSE (Level 2) or core maths (Level 3), supporting access to higher levels of STEM study. We discuss the possibility of four pathways in greater detail below.

- Teacher supply to teach mathematics / mathematical qualifications needs to grow, but this relies on clarity that such teaching will be highly supported in the system for education funding. Schools and colleges needs strong signals from government that they will be supported in offering these courses, so that participation post-16 can grow.

Pathway 1 – Functional skills and the GCSE Mathematics resit

The current national policy is for students with insufficient prior attainment in GCSE mathematics to re-sit the qualification, however low success rates in re-sit courses need to be addressed and repeating the course may not ultimately help to raise mathematical skills. We agree with the Wolf Report's recommendation that "Post-16, English and Mathematics should be a required component of study programmes for those without good GCSEs in these subjects" including for apprentices, using stepping-stone qualifications if required. [9] The Functional Skills qualification, which is undergoing reform, could be a suitable stepping stone qualification post-16, as well as a suitable qualification for adult skills.

[7] Education Funding Agency (2016) '16 to 19 funding: maths and English condition of funding' (webpage), available at: https://www.gov.uk/guidance/16-to-19-funding-maths-and-english-condition-of-funding
[8] Cambridge Assessment (2015) 'Should we make the pass rate harder? Mark Dawe and Nick Gibb' [webpage] Available at: http://cambridgeassessment.org.uk/insights/should-we-make-the-gcse-pass-rate-harder/
[9] Wolf Report: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/180504/DFE-00031-2011.pdf page 10.

A revised Functional Skills in Mathematics should include the application of the statistics cycle, and the interpretation of statistical information, including some basic statistical calculation, such as mean, and median. This would involve understanding and assessing existing data and statistics in realistic contexts (eg nutrition information, election leaflets), and manipulation of data with suitable technology, such as spreadsheets.

Pathway 2 – Core Maths

With Core Maths, students who have attained GCSE mathematics to a satisfactory level develop their general numerical and quantitative skills, maintaining and extending the skills they gained at GCSE to attain a 'Level 3' qualification that is smaller than an AS Level.

Core Maths focuses on realistic contexts and applied mathematics, including the use of realistic data and statistical problem-solving. This provides a good foundation for future destinations, whether higher education, further education, apprenticeships or work.

We believe that teaching and participation in this pathway should grow through the offer of key teaching resources, and through partnership with universities such as those that have developed quantitative methods 'Q-Step' centres. The possibility for progression from Functional Skills into Core Maths should also be explored.

Pathway 3 – AS and A level Mathematics and Further Mathematics

Through A level Mathematics, students' mathematical and statistical skills are developed, including in statistics. This makes ideal preparation for further and higher education in STEM subjects. A level Mathematics includes compulsory statistics components, taught using realistic data in realistic contexts, whilst maintaining mathematical rigour. Accompanying this with A Level Further Mathematics is immensely valuable for students aiming to pursue Mathematics and Statistics as their main degree specialism in higher education.

We believe participation in Mathematics A Levels should continue to grow with support in particular for Further Maths, and through the Further Maths Support Programme.

Attention needs also to be paid to the paths by which students feel encouraged to take A Level mathematics. In our view, AS Level has encouraged students to participate who would not otherwise enter the A Level Mathematics pathway, and so any damping down of AS Level participation post-reforms needs to be countered. To recognise the importance of the mathematics pathway, AS Level Mathematics should continue to be supported as a qualification in its own right, giving students the option of continuing to A Level Mathematics in their second year.

Pathway 4 – AS and A level Statistics

AS and A level Statistics develops students' applied statistical and data analysis skills, making ideal preparation for further study in psychology, biology, finance, and social science degrees focusing on quantitative research, quantitative analysis and reasoning with data. For those students confident about their mathematical abilities, and their future career path in a quantitative subject, A level Statistics offers them an opportunity to get a head-start on their future studies. We believe participation should grow through partnership with universities.

Q. What can be done to get more students choosing maths post-16?

There are strong interests in broad participation across STEM qualifications in general post-16, supported by the finding of the Wolf Review which found that "If young people drop maths and science at 16 it effectively becomes impossible for them, in the future, to move to a quantitative or science-based course." [10] Research into curriculum content has found that although mathematical content is increasingly specified in reformed A Levels, quantitative skills are not reliably benchmarked and reinforced, given the variability in subject teaching and assessment options.[11, 12] More accessible maths-specifics pathways are therefore needed.

There has been some success in recent years at raising AS Mathematics, A Level Mathematics and A Level Further Mathematics participation. However there is a big gap post-16 between Level 2 (represented in GCSE Mathematics as well as in Level 2 Functional Skills) and Level 3 (eg Mathematics and Further Mathematics A Levels), which could be bridged by the pursuit of smaller Level 3 qualifications (AS Level Mathematics, and Core Maths).

There needs to be a greater understanding that omitting mathematics from studies post-16 hampers students' professional and educational options in future. To tackle participation, students and schools need up-to-date resources on careers and higher study valuing mathematics (GCSE and A Level, and the alternatives). Young people should be aware that demonstrating interests and skills in mathematics will mean they are more competitive in the job market, and the qualifications must be applicable in the pathways they want to pursue.

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[10] Wolf, A. (2011) *Review of Vocational Education* (PDF) Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/180504/DFE-00031-2011.pdf

[11] Nuffield Foundation (2012) *Mathematics in A Level Assessments* http://www.nuffieldfoundation.org/sites/default/files/files/Maths_in_A_level_Assessments_Nuffield_Foundation_WEB.pdf

[12] ACME and RSS (2015) *Embedding statistics at A Level* http://www.rss.org.uk/Images/PDF/publications/embedding-statistics-at-a-level.pdf

Pressure on timetabling is a further issue both for schools and for students. Post-16 the pathways for mathematical learning diverge as approximately half of students choose a narrower range of subjects for A Level and as other students switch to technical and vocational options. The education system is under pressure to teach the most competitive options. For students taking technical options, we think that the inclusion of English, maths and digital skills in a recommended 'common core' for has some promise.[13] Students taking academic options and A Levels, who are pursuing no other mathematics pathway, should also be effectively incentivised to take up key enhancement courses to develop their core skills in mathematics. These are needed for application in subject-based research at undergraduate level, of which mathematical and quantitative skills form an increasingly important part.

To raise participation and inclusion in mathematics, our universities, higher education institutes and employers must signal that they value mathematical qualifications that are 'less-than' A Level, including AS Level Mathematics, and Core Maths. The Royal Statistical Society plans to play its part by developing its accreditation of courses in statistics.

We also recommend that there should be continued investment in national support programmes for teachers of mathematics, especially to continue the established Further Mathematics Support Programme, and to develop a similar strength of support for maths teachers at lower levels, for example to ensure that Core Maths courses can be offered and that support for mathematics in other subjects takes place. Teacher capacity will otherwise pose a major barrier against growing participation (as discussed further below).

Q. What are the main challenges to increasing provision of post-16 mathematics in schools and colleges? How can these be addressed?

Teacher supply is a major barrier. All countries face challenges recruiting sufficient subject specialist teachers. Following education reforms in the last parliament, 2016 sees the bedding in of many of the revised qualifications for secondary schools in England. To implement reformed qualifications and standards, to respond to the increased volume of mathematical content proposed for subjects in secondary schools, and to make sure that students are inspired and enthused by statistics and data, the Government needs to ensure that there are sufficient teachers, with sufficient skills. The introduction of compulsory courses for universal mathematics education would be a further major shift and needs to be introduced on a planned and phased basis. Support

[13] DfE & BIS (2016) 'Post-16 skills plan' (PDF), available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/536043/Post-16_Skills_Plan.pdf

for learning need to be offered in order to fit core mathematical skills into curriculum teaching time and to limit the time demands on subject specialist teachers who are in too limited supply.

Q. How strong is the case for all students continuing to study maths post-16? How feasible is this in the medium and long term?

As we have set out above, we believe that there is a strong case for this but that a singular mathematics pathway does not suit the purpose. We also believe that given teacher supply and qualification constraints it is unfeasible in the medium term, but ought to be feasible in the long term with policy changes.
The definition of mathematical skills and quality of assessment, including within science and in social science subjects, requires close attention. The government needs to bring into place a long-term, planned process for regular curriculum review, independent of ministers, which needs to be properly resourced with independent subject expertise. Long term support also needs to be assured for teacher training and teacher development at teaching mathematical content.

Q. What potential is there for different delivery teaching models in post-16 mathematics?
Q. What more could be done to improve mathematics teaching capacity and professional support for post-16 maths teachers?

The shortage of mathematics subject specialists is not going to be filled in the short run. Resource hubs, shared course content and support for teachers become more important so that we can achieve more with a teacher workforce who are already insufficient in number. Serious consideration should be given to supporting mathematical qualifications that would require less teaching time and more self-study, such as the flipped classroom model. Such courses could have mass appeal and easy accessibility for students and that would raise applicable skills without competing too much with AS and A Level study. The Further Mathematics Support Programme has some experience in developing high quality resources that can help the available workforce go further. It is clear that smart investment in teacher training is needed, however investment in mathematics support programmes is also needed, and helps the existing workforce.

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