Observatory for Mathematical Education submission to DfE Curriculum and Assessment Review call for evidence

22 November 2024

This is the Observatory for Mathematical Education's (OME) submission to the Department for Education Curriculum and Assessment Review call for evidence. The submission covered focused on the questions that are of particular relevance to the OME's expertise in mathematical education.

Section 2: General views on curriculum, assessment, and qualifications pathways

10 What aspects of the current a) curriculum, b) assessment system and c) qualification pathways are working well to support and recognise educational progress for children and young people?

Since 1997, primary mathematics in England has seen considerable, and sustained, improvement. In TIMMS 1995, at Year 5, pupils in England performed below the international average; in contrast, in the last international survey, TIMSS 2019, Year 5 pupils performed substantially above the international average (Richardson et al., 2020).

Much of this improvement is as a result of the National Numeracy Strategy (NNS), which was introduced in 1999 to all English Primary Schools. A large-scale longitudinal study of primary mathematics, the Leverhulme Numeracy Research Programme, compared mathematical performance at Year 4 before and after the introduction of the NNS and found a positive effect of 0.18 (Cohen's d) as well as a narrowing of the gap between the most and least disadvantaged pupils (Brown et al., 2003). We note that this system-wide effect of the NNS is larger, or at a similar scale, to the impacts achieved by almost all of the promising interventions trialled through the Education Endowment Foundation. There have been further gains in the intervening years, with reforms such as the Teaching for Mastery programme, but these are much smaller than the initial gains associated with the NNS.

We consider that it will be difficult, and potentially very costly, to make wholescale improvements to primary mathematics in the absence of improvements elsewhere in the system, particularly at Key Stage 3 and beyond. Hence, whilst we consider some changes to curriculum and assessment in primary mathematics to be necessary, the main focus for reform should be elsewhere.

11 What aspects of the current a) curriculum, b) assessment system and c) qualification pathways should be targeted for improvements to better support and recognise educational progress for children and young people?

There needs to be considerable focus on mathematics at Key Stage 3 and beyond. The high level of attainment at primary mathematics is not sustained into Key Stage 3 and beyond. In TIMSS 2019, Year 9 pupils performed only slightly above average (Richardson et al., 2020), whilst, at age 15, the latest PISA survey in 2022 shows a very substantial pandemic-related dip (Ingram et al., 2023). Moreover, a comparison of attainment over time involving a nationally representative sample suggests that achievement in some key aspects of multiplicative reasoning and algebra has fallen since the 1970s (Hodgen et al., 2024).

This problem goes beyond Key Stage 3. The most recent international survey of adult skills in 2013 indicates that England's performance in numeracy was significantly below the international average (Wheater et al., 2013). Moreover, the OECD survey indicated that young adults' numeracy skills were worse than those of older adults, meaning that numeracy skills have worsened over time. Research has shown that the continued study of numeracy and literacy in upper secondary education is a feature of successful education systems and results in greater adult numeracy and literacy skills (Pensiero & Green, 2018). Yet, in England, most pupils stop studying mathematics and English at age 16 after taking GCSEs. Over a decade ago, research showed that England, and the other UK nations, were almost unique internationally in this low participation post-16 (Hodgen et al, 2010). Despite reform over the past decade, England's participation in mathematics and literacy remains comparatively low. Indeed, well-intentioned reforms such as the GCSE retakes policy have had unintended, negative effects.

Almost a third of England's 16-year-olds do not achieve grade 4 at GCSE in mathematics and are then required to retake this examination, often repeatedly 'failing'. It is vital that these young people do achieve a Level 2 qualification in mathematics (and English) and that we enable them to achieve good skills in numeracy. However, the GCSE resits policy has not achieved this.

Each year, around 250,000 of England's pupils successfully achieve a grade 4, 5 or 6 in GCSE mathematics and cease to study mathematics. In general, the current A-level mathematics is not an appropriate pathway for these pupils. A central aim of the Core Maths suite of qualifications was to enable this group to develop their mathematical, quantitative and problem-solving skills. However, the Core Maths qualifications are not yet universally available (Gill, 2024) and are not currently set at an appropriate level of difficulty.

For students who achieve a grade 7, 8 or 9 in GCSE mathematics then A level mathematics is the default option for those wishing to continue with mathematics. A level mathematics is the most popular A level with over 107000 entries in 2024. However, unlike mathematics at GCSE or degree level, there is a large attainment gap with male students significantly more likely to achieve top A level grades compared to female students (Brignell et al., 2024).

For those achieving grade 9 in GCSE mathematics, then A level Further Mathematics is an option, but it is not available in all sixth forms. The DfE-funded

Advanced Maths Support Programme (AMSP) is working to support more schools and colleges deliver this qualification (Walker et al., 2020). While Further Mathematics is necessary to access maths degrees at elite universities, students who take Further Mathematics are no more likely to achieve better maths degree outcomes, and the qualification could be reformed to better prepare students for maths degrees (Brignell et al., 2024).

Section 3: Social justice and inclusion

12 In the current curriculum, assessment system and qualification pathways, are there any barriers to improving attainment, progress, access or participation (class ceilings) for learners experiencing socioeconomic disadvantage?

Noyes et al.'s (2023) analysis of National Pupil Database (NPD) and Higher Education Statistics Agency (HESA) data indicates that Key Stages 3 and 4 are associated with a growing attainment gap between the most and least disadvantaged pupils. Many students from economically disadvantaged backgrounds, who achieved highly at Key Stage 2, do not achieve sufficiently high grades at GCSE to be considered for A-level mathematics. However, pupils from disadvantaged backgrounds, who attain highly at GCSE, are as likely to progress to A level Mathematics as their more affluent peers. In addition, Key Stage 3 is associated with a growing gap between the highest and lowest attaining pupils. In particular, Hodgen et al.'s (2024) analysis of progress in multiplicative reasoning and algebra indicates that the lowest attaining pupils, who are disproportionately from disadvantaged backgrounds, fail to make any progress across Key Stage 3.

13 In the current curriculum, assessment system and qualification pathways are there any barriers to improving attainment, progress, access or participation which may disproportionately impact pupils based on other characteristics (e.g. disability, sexual orientation, gender, race, religion or belief etc.)

Noyes et al.'s (2023) analysis shows that girls' participation in A level Mathematics is lower than that of boys and this trend continues into undergraduate study in mathematics. However, Core Maths achieves a better gender balance (48% female in 2023) suggesting greater female participation in level 3 maths could be facilitated be expanding this qualification or AS level Mathematics to support learners not taking A level Mathematics.

Note that students of Asian ethnicity are more likely to achieve higher grades in GCSE mathematics than other ethnicities which may be due to different cultural values around the value of mathematics (Brignell et al., 2024, Griffiths, 2024).

The pre-school education system is out of the scope of this review. However, it is important to recognise that many educational inequalities arise prior to formal schooling (see, e.g., Education Policy Institute, 2024) and there is a need to address these inequalities in the EYFS curriculum.

Section 4: Ensuring an excellent foundation in maths and English

16 To what extent does the content of the national curriculum at primary level (key stages 1 and 2) enable pupils to gain an excellent foundation in a) English and b) maths? Are there ways in which the content could change to better support this aim?

Although primary mathematics is performing well in general, there are a number of areas where we believe changes would be beneficial, as recommended by the Royal Society's (2024) Mathematical Futures Report. Many of these are at a level of detail that may be best considered by a specialist mathematics curriculum group rather than the high-level Curriculum and Assessment Review group. We note that substantial practice-related research and guidance is available to support, and inform, these considerations (e.g., Fuchs et al, 2021; Hodgen et al., 2020, 2018).

However, three broad areas are of particular importance and we believe are necessary:

First, over the past decade, there has been too much emphasis placed on outdated pencil-and-paper techniques for calculation, and too little emphasis on mental methods and estimation, as was the case with the NNS. Mental methods and estimation skills are far more important skills than long division (and the like) for life and work in today's world (Hoyles et al., 2010). Rebalancing this would be a relatively straightforward change and could build on the considerable NNS resources.

Second, we believe that the Year 1 mathematics curriculum content could be somewhat reduced to focus more closely on key foundational concepts and help close the attainment gap early. For example, fractions could be removed. Introducing these concepts in Year 2, as was the case prior to the 2014 National Curriculum, would be a relatively straightforward change and would create space in the Year 1 curriculum.

Thirdly, for some time, the English mathematics curriculum has placed very little emphasis on geometry and spatial reasoning in comparison to other systems (e.g., Hoyles et al., 2002). Research suggests that spatial reasoning is associated with greater mathematical attainment at primary (Gilligan et al., 2017) and beyond (Atit et al., 2021). Hence, we agree with the Royal Society (2024) that there is a very good case for strengthening these skills at primary. We caution, however, that such a change is not straightforward and is likely to take some time. Our primary teachers have been educated in a geometry-light mathematics curriculum and, hence, will need substantial support to develop their spatial reasoning skills. The mathematics curriculum is already considered by many to be too content heavy, so some content would then need to be removed. Moreover, introducing more geometry and spatial skills in primary would require similar changes in secondary mathematics education.

17 To what extent do the English and maths primary assessments* support pupils to gain an excellent foundation in these key subjects? Are there any changes you would suggest that would support this aim?

Many stakeholders consider that the burden of assessment is too great in primary generally, causing unnecessary stress and anxiety for pupils and teachers and taking time away from teaching. However, recent research suggests that Year 6 teachers do not experience long term additional stress as a result of the Key Stage 2 National Tests (Jerrim et al, 2024). We would caution against abandoning a large number of assessments in the absence of more rigorous evidence on the effects, both positive and negative.

Nevertheless, we consider two aspects of assessment at primary do require some change. The Multiplication Tables Check at Year 4 is narrowly focused on the recall of multiplication facts and would be better adapted as a more rounded assessment of mental calculation. Prior to 2016, mental calculation was included as an element of KS2 National Assessments. In general, whilst we support the use of a baseline assessment in principle, we consider there may be an opportunity for the Reception Baseline Assessment to be adapted to provide better formative information for teachers and schools.

18 To what extent does the content of the a) English and b) maths national curriculum at secondary level (key stages 3 and 4) equip pupils with the knowledge and skills they need for life and further study? Are there ways in which the content could change to better support this aim?

As we have already indicated, there is a need to target mathematics at Key Stages 3 and 4. The Royal Society's (2024) Mathematical Futures Report makes a strong case for change. We support the Royal Society's recommendations for a revised curriculum that integrates data, statistics, and computational tools coherently with mathematics, and for the introduction of a low stakes competency assessment to be taken at the end of Key Stage 3. Compared to education systems in USA and New Zealand, current data education is too theoretical, isn't given enough emphasis for a modern data-driven society, and doesn't include enough authentic problem solving in real-world scenarios (Royal Statistical Society, 2024).

We note that there is much less practice-related research and guidance available to support, and inform, these considerations at secondary than there is for primary. However, the Education Endowment Foundation has commissioned a team (including Jeremy Hodgen of the Observatory for Mathematical Education) to synthesis the evidence relating to secondary mathematics, which is due to report in the new year.

19 To what extent do the current maths and English qualifications at a) pre-16 and b) 16-19 support pupils and learners to gain, and adequately demonstrate that they have achieved, the skills and knowledge they need?

The current qualification system is not fit for purpose. The Royal Society's (2024) Mathematical Futures Report makes a strong case for change. We support the Royal Society's recommendations for the development of a single mathematical and data education (MDE) qualifications framework which enables all students to continue to study MDE to 18. The framework would give clearer distinction to the mathematics learned in preparation for advanced mathematics, that learned in support of real-world problem solving, and that learned to support mathematical skills within other subjects.
The current single GCSE mathematics and limited range of level 3 mathematics qualifications fail to meet these multiple aims. Arguably, A level Mathematics and Further Mathematics are too similar, with the latter just containing more-of-the-same style of mathematics as the former, and hence offering little additional benefit (Brignell et al., 2024). Reforming the two A levels so one is more theoretical, and one is more focused on using mathematical and data skills to solve open-ended real-world problems, is a step towards the Royal Society's recommendations, as would be a similar pair of qualifications at GCSE level.

20 How can we better support learners who do not achieve level 2 in English and maths by 16 to learn what they need to thrive as citizens in work and life? In particular, do we have the right qualifications at level 2 for these 16-19 learners (including the maths and English study requirement)?

As we have already noted, the current GCSE resits policy is not supporting learners who do not achieve level 2 in English and maths by 16 to learn what they need to thrive. We consider there is a good case for a GCSE qualification with reduced content and a greater focus on the application and use of mathematics. Such a qualification should be developed as an integral part of for the development of a single mathematical and data education qualifications framework, as recommended by the Royal Society (2024).

21 Are there any particular challenges with regard to the English and maths a) curricula and b) assessment for learners in need of additional support (e.g. learners with SEND, socioeconomic disadvantage, English as an additional language (EAL))?

After controlling for prior attainment at Key Stage 2, those with English as an additional language do well in GCSE mathematics compared to those with English as a first language (Brignell et al., 2024).

Only half of students from economically disadvantaged backgrounds, who achieved highly at Key Stage 2, achieve sufficiently high grades at GCSE to be considered for A-level mathematics. This compares to three-quarters for those from economically advantaged backgrounds (Noyes et al., 2023).

Section 9: Other issues on which we would welcome views

54 Do you have any further views on anything else associated with the Curriculum and Assessment Review not covered in the questions throughout the call for evidence?

The Observatory for Mathematical Education (OME) is currently conducting a very large longitudinal programme of research into mathematics education. We expect that this research will produce evidence to inform the Review's considerations and would welcome discussions with the Review about the evidence that could be provided. The research currently being carried out by is outlined below.

Trend Analysis
The OME has set up the country's only dedicated data lab for mathematical education using data from the Department for Education and the Higher Education Statistics Agency. Using national data, we can establish who are the students most likely to excel under the current system. Some patterns are well established, such as lower progress by students from poorer backgrounds and higher participation by male students, but the underlying picture is much more nuanced. If we are to address inequalities in the system, we need a better understanding of the interaction between sex, socio-economic class, ethnicity and each student's school/college/university and regional context. Consistently analysing these trends over time and finding pockets of 'over-achievement' will give clues as to which policies and interventions are making a positive difference.

Our trend analysis is underpinned by a cohort approach. Each cohort going through the system experiences a different combination of policies and pedagogies as strategies come and go. The effect of a change at early years level will only be felt in postgraduate education 20 years later. We therefore track each cohort to pinpoint where and when in the system things are going well and where there are challenges. By following individuals into adulthood and employment we can measure the importance of mathematics for the social mobility of the individual and the economic return for the country.

Cohort Studies
The OME is running the largest ever set of longitudinal studies of mathematics students in England involving tens of thousands of children and young people. Over a period of 7 years, we are tracking students' attitudes to mathematics every year:

- in primary schools: starting with reception year in 2024/5 and finishing with year 6 in 2030/31.
- in secondary schools: starting with year 7 in 2024/5 and finishing with year 11 in 2028/29, and beyond into post-16 education (e.g. A level) until 2030/31 for those who continue with mathematics.
- in colleges and universities: tracking multiple cohorts through A level, undergraduate, and postgraduate maths courses.

The aim of the cohort studies is to understand how learner outcomes are shaped by learner attitudes to mathematics and how both are shaped by factors at individual, family, classroom, institution and national levels. We might hypothesise that a learner's attitude to mathematics is the combined effect of their own personality, the perspectives of their family and friends, the skill of their teachers, the curriculum, the learning resources available, how they are assessed, who they learn with, extra-curricular opportunities and many other factors. These things, in turn, are influenced by policies and funding at national and institution level. Understanding the complex web of connections between these factors is the goal of the cohort studies.

As well as the surveys of students, we will also be surveying parents and teachers to get their perspective on the importance and learning of mathematics. In addition, our team of researchers will be visiting dozens of schools, colleges and universities to observe the different contexts in which students learn. Where the trend analysis will give us national patterns of progression, attainment and participation by sex, socio-economic status, ethnicity and region, the cohort studies will help explain why those patterns occur.

References

Atit, K., Power, J.R., Pigott, T., Lee, J., Geer, E.A., Uttal, D.H., Ganley, C.M. & Sorby, S. (2021). Examining the relations between spatial skills and mathematical performance: A meta-analysis. *Psychonomic Bulletin & Review, 29*, 699–720. https://doi.org/10.3758/s13423-021-02012-w

Brignell, C., Noyes, A., Jacques, L. (2024). The mathematics pipeline in England: inclusion and the excellence stream, *Teaching Mathematics and its Applications* https://doi.org/10.1093/teamat/hrae005

Brown, M., Askew, M., Millett, A., & Rhodes, V. (2003). The key role of educational research in the development and evaluation of the National Numeracy Strategy. *British Educational Research Journal, 29*(5), 655-672.

Education Policy Institute (2024) EPI Annual report 2024. https://epi.org.uk/annual-report-2024-disadvantage-2/

Fuchs, L. S., Newman-Gonchar, R., Schumacher, R., Dougherty, B., Bucka, N., Karp, K. S., Woodward, J., Clarke, B., Jordan, N. C., Gersten, R., Jayanthi, M., Keating, B., & Morgan, S. (2021). *Assisting Students Struggling with Mathematics: Intervention in the Elementary Grades (WWC 2021006).* National Center for Education Evaluation and Regional Assistance (NCEE), Institute of Education Sciences, U.S. Department of Education. http://whatworks.ed.gov/

Gill, T. (2024). Core Maths: Who takes it, what do they take it with, and does it improve performance in other subjects? *Research Matters, 38*, 48–65. https://doi.org/10.17863/CAM.111628

Gilligan, K.A., Flouri,E. & Farran, E.K. (2017) .The contribution of spatial ability to mathematics achievement in middle childhood. *Journal of Experimental Child Psychology, 163*, 107–125. http://dx.doi.org/10.1016/j.jecp.2017.04.016

Griffiths, L., (2024). *Progression at age 16 of young people from underrepresented backgrounds towards careers in STEM*, Education Policy Institute. United Kingdom. Retrieved from https://coilink.org/20.500.12592/4x0kpvw

Hodgen, J., Barclay, N., Foster, C., Gilmore, C., Marks, R., & Simms, V. (2020). *EEF Review of Evidence on Early Years and Key Stage 1 Mathematics Teaching*. Education Endowment Foundation.

Hodgen, J., Coe, R., Brown, M., & Küchemann, D. (2024). Educational Performance over Time: Changes in Mathematical Attainment between 1976 and 2009 in England. *Implementation and Replication Studies in Mathematics Education, 4*(1), 83-124. https://doi.org/10.1163/26670127-bja10018

Hodgen, J., Foster, C., Marks, R., & Brown, M. (2018). *Evidence for Review of Mathematics Teaching: Improving Mathematics in Key Stages Two and Three*. Education Endowment Foundation.

Hoyles, C., Foxman, D., & Küchemann, D. (2002). *A comparative study of geometry curricula*. QCA.

Hoyles, C., Noss, R., Kent, P., & Bakker, A. (2010*). Improving mathematics at work: The need for techno-mathematical literacies.* Routledge.

Ingram, J., Stiff, J.,Cadwallader, S., Lee, G., & Kayton, H. (2023). *PISA 2022: National Report for England*. Department for Education.

Jerrim, J., Allen, R., & Sims, S. (2024). High Stakes Assessments in Primary Schools and Teachers' Anxiety About Work. *Educational Assessment, 29*(2), 59-74. https://doi.org/10.1080/10627197.2024.2350961

Noyes, A., Brignell, C., Jacques, L., Powell, J., & Adkins, M. (2023). *The mathematics pipeline in England: Patterns, interventions and excellence.* Centre for Research in Mathematics Education (CRME). https://nottingham-repository.worktribe.com/OutputFile/21372569

Pensiero, N., & Green, A. (2018). The effects of post-compulsory education and training systems on literacy and numeracy skills: A comparative analysis using PISA 2000 and the 2011 survey of adult skills. *European Journal of Education, 53*(2), 238-253. https://doi.org/https://doi.org/10.1111/ejed.12268

Richardson, M., Isaacs, T., Barnes, I., Swensson, C., Wilkinson, D., & Golding, J. (2020). *Trends in International Mathematics and Science Study (TIMSS) 2019: National report for England (Research Report RR1086).* Department for Education.

Royal Statistical Society (2024). *Recommendations for the statistics curriculum in the UK*. https://rss.org.uk/RSS/media/File-library/Policy/2024/Recommendations-for-statistics-curriculum-in-the-UK-full-paper-final.pdf

The Royal Society (2024). *A new approach to mathematical and data education*. https://royalsociety.org/news-resources/projects/mathematical-futures/

Walker, M., Straw, S., Bradley, E., Jones, L. and Harland, J. (2020). *Evaluation of the Advanced Mathematics Support Programme (AMSP): Research report*. NFER: Slough.

Wheater, R., Burge, B., Sewell, J., Sizmur, J., J, W., & Williams, J. (2013). *The International Survey of Adult Skills 2012: Adult Literacy, Numeracy and Problem Solving Skills in England (BIS Research Paper Number 139)*. BIS.