# Maths Horizons

## How England should reform maths education for the age of AI

## Executive overview

May 2025

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## Background

Maths Horizons was launched in September 2024 to develop evidence, analysis and recommendations about the future of maths curriculum and assessment in England. As an independent initiative, our work is intended to support the government's Curriculum and Assessment Review, as well as the wider debates about the future of England's education system and economy.

Maths Horizons is chaired by Prof Lord Lionel Tarassenko, President of Reuben College, Oxford. It is co-led by Dr Helen Drury and David Monis-Weston, both former maths teachers and education charity founders. They are supported in their work by an Executive Group of advisors, which includes teachers, leaders and experts from primary, secondary and further education, and representatives from academia and industry.

Over the last nine months, we have conducted large-scale polling, with nationally representative samples of 10,000 teachers, 2,000 parents, 2,100 students, 2,200 employers and 2,000 employees. We have heard from hundreds of experts through interviews and consultation feedback, as well as roundtable discussions and school visits. Building on these insights, Maths Horizons is excited to share its first major publication: "How England should reform maths education for the age of AI".

## Summary

**Maths Horizons' vision is to raise standards in maths at every level, from ensuring that students leave education with secure fundamental knowledge, to an ambitious increase in advanced mathematical study. This report offers a blueprint to reform maths curriculum and assessment, which would support the aspiration for England to become one of the top-performing countries in the world for maths.**

As the "age of AI" begins, England must reckon with transformational opportunities and challenges. England is an early leader in AI and related industries, a position underpinned by its mathematical and computational expertise. In our polling, many companies – especially "frontier tech" companies – told us that they place great value on maths, with 78% of frontier tech companies telling us that they expect maths skills to become more important over the next two years[1]. Clearly, England's future success will rely heavily on maths education.

Over the past few decades, successive governments have undertaken programmes of reform to strengthen maths education in England, which have produced a sustained improvement in outcomes. In the 2023 TIMSS assessment, England ranked as one of the top-performing countries in maths outside East Asia[2]. More students than ever achieve a "standard pass" in GCSE Maths by age 19, the rate having increased from 53% in 1995[3] to around 80% today[4]. Maths is now the most chosen A-Level course, with more than 100,000 entries in 2024[5].

Yet if England is to thrive in the age of AI, it must overcome some persistent challenges. One is that teachers widely believe that England has a "crowded curriculum", which contributes to students being rushed through content, without knowledge being secured thoroughly. Another is that exams are not comprehensively testing for fundamental knowledge. In fact, students can achieve a standard pass in the Higher Tier GCSE Maths exam by obtaining as little as 14% of the available marks[6].

More should also be done to support students to progress in maths beyond age 16. Despite retakes being compulsory for students who do not achieve a standard pass at age 16, around 20% of all students still do not achieve one by age 19, after an estimated 1,600 hours of maths[7]. At the other end, too few students progress to advanced mathematical study, even if they excelled in GCSE Maths. Unlike many peer countries, students in England can stop studying maths at age 16 and so, for most, their journey ends there.

Given the decades of progress that England has already made – and the exemplary performance that other education systems have shown to be possible – we believe that England can and should aspire to be one of the top-performing countries in the world for maths.

Our vision is to raise standards at every level, so that almost all students leave education having achieved at least a standard pass in GCSE Maths, and that there is a significant increase in the number of students who continue with maths beyond age 16 for advanced mathematical study.

To help make this vision concrete, this report sets out three objectives and makes seven recommendations.

We believe that, if the education system can align around high expectations, these objectives are achievable within the next decade. We believe that our recommendations can be implemented quickly and effectively, provided that there is purposeful action from the government, and support from a range of stakeholders.

In the months ahead, Maths Horizons will continue to undertake detailed analysis to support curriculum and assessment design, and on-going engagement across education, academia and industry. We look forward to developing a shared vision for England to be one of the top-performing countries in the world for maths.

| Objectives for 2035 | |
|---|---|
| 1 | Ensure that students secure the fundamental maths knowledge needed to navigate education, work and daily life with confidence. |
| 2 | Ensure that students leave education equipped to use their maths to solve abstract and real-world problems with flexibility. |
| 3 | Build the pipeline of students who continue with maths beyond age 16 for advanced mathematical study. |

| Recommendations | | |
|---|---|---|
| Curriculum | 1 | **Design a curriculum for mastery** that carefully maps knowledge progression within and between sub-domains of maths. |
| | 2 | **Rebalance content from upper primary to lower secondary**, allowing more time for knowledge to be secured when it is first introduced. |
| | 3 | **Increase the rigour of mathematical reasoning and problem solving for all students**, including specifying more clearly what, when and how students should learn. |
| Assessment | 4 | **Introduce low-stakes gateway checks of fundamental knowledge**, to be administered nationally at specified points in new knowledge-progression maps. |
| | 5 | **Reform the Key Stage 2 SAT exams** to increase the marks required to achieve the "expected standard"; and to rigorously test mental methods and problem solving. |
| | 6 | **Reform the GCSE exams** to ensure that a "standard pass" demonstrates secure fundamental knowledge; to rigorously test problem solving; and to improve the retake system. |
| Pathways | 7 | **Explore a maths entitlement for 16- to 19-year-olds**, which should aim to promote take-up of Core Maths; to review the content of A-Level Maths; and to pilot a standalone A-Level Further Maths course. |

## Maths education in the age of AI

At the start of 2023, Chat GPT was able to achieve a standard pass in GCSE Maths[8]. At the start of 2024, the AI Mathematical Olympiad Prize was launched[9]; a competition with a $5m prize for the first open-source AI model capable of performing at a gold medal-standard in the annual International Mathematical Olympiad. The latest results show that AI models can solve the majority of problems that are equivalent in difficulty to those in national maths competitions taken by the top 0.1% of 17-year-olds[10].

It is likely that, in the not-too distant future, AI will be capable of doing all the maths that most people need. We will be able to ask it maths questions and receive instant answers, all done in natural language, without having to overly-rely on symbolic representation. This all raises deep questions about the purpose of maths education, including "Will we even need it?"

Our answer is a hard "yes". Generative AI is a probabilistic black box, so the "human in the loop" must still interpret and verify its solutions. Maths knowledge is needed to craft prompts, spot subtle errors in replies and refine approaches to get better answers. A society fluent in mathematics can scrutinise the algorithms that increasingly govern public life, instead of surrendering decisions to them. Students will need to continually adapt to new developments in AI, for which the best preparation may be foundations in "pure maths" – topics like number theory, geometry and algebra – and well-practised problem-solving skills.

The government's National AI Strategy[11] notes that England's strength in AI has been built on its mathematical and computational expertise. Maths Horizons polling found that many companies – especially "frontier tech" companies – place great value on maths, with 78% of frontier tech companies telling us that they expect maths skills to become more important over the next two years. In particular, they told us that they highly value the critical thinking skills that are associated with mathematical reasoning.

## Progress and challenges

Over the past few decades, successive governments have undertaken programmes of reform to strengthen maths education in England. The National Curriculum in 1988[12], and the National Numeracy Strategy in 1999[13], ushered in a new, standards-driven approach to maths teaching. Subsequent National Curriculum reforms in 2014[14] drove up rigour further by setting age-related expectations, increasing the difficulty of national exams and promoting a new "teaching for mastery"[15] approach.

These reforms produced a sustained improvement in outcomes. In the 2023 TIMSS assessment, England ranked as one of the top-performing countries in maths outside East Asia. More students than ever achieve a standard pass in GCSE Maths by age 19, the rate having increased from 53% in 1995 to around 80% today. There has also been impressive growth in take-up of A-Level Maths, now the most chosen A-Level, with over 100,000 entries in 2024, representing over half of all students that took A-Levels.

Yet if England is to thrive in the age of AI, it must overcome some persistent challenges. One is that teachers widely believe that there is a "crowded curriculum" with "too much maths to cover"[16].

Consequently, students are rushed through content, without securing the knowledge, leading to re-teaching later. At the same time, exams are not comprehensively testing for fundamental knowledge. In fact, students can achieve a "standard pass" in the Higher Tier GCSE Maths exam by obtaining as few as 14% of the available marks.

More should also be done to support students to progress in maths beyond age 16. Despite retakes being compulsory for students who do not achieve a standard pass at age 16, around 20% of all students still do not achieve one by age 19, after an estimated 1,600 hours of maths. At the other end, too few students progress to advanced mathematical study, even if they excelled in GCSE Maths. Unlike many peer countries, students in England can stop studying maths at age 16 and so, for most, their journey ends there.

## Vision and objectives

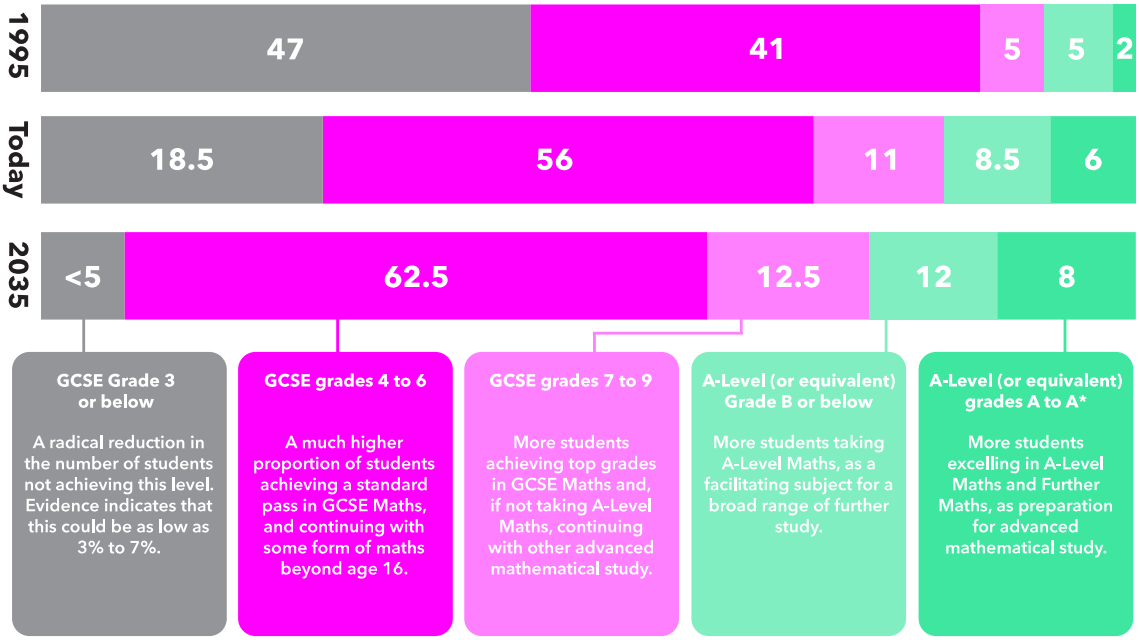
Despite these challenges, there are good reasons to believe that standards can be raised further in England. Research shows that mathematical learning difficulties, such as dyscalculia, affect only 3% to 7% of students[17], far fewer than the 21% who did not achieve a standard pass in GCSE Maths by age 19 in 2024[18]. This is backed up by data from the Netherlands, where fewer than 10% of students do not attain the equivalent of a standard pass by age 19[19]; and Singapore, where 41% of students were classified as "top performers" in maths in the 2022 PISA assessment (UK: 12%; OECD average: 9%)[20].

Given the decades of progress that England has already made – and the exemplary performance that other education systems have shown to be possible – Maths Horizons believes that England can and should aspire to be one of the top-performing countries in the world for maths.

Our vision is to raise standards at every level, so that almost all students leave education having achieved at least a standard pass in GCSE Maths, and that there is a significant increase in the number of students who continue with maths beyond age 16 for advanced mathematical study.

| Objectives for 2035 | |
|---|---|
| 1 | Ensure that students secure the fundamental maths knowledge needed to navigate education, work and daily life with confidence. |
| 2 | Ensure that students leave education equipped to use their maths to solve abstract and real-world problems with flexibility. |
| 3 | Build the pipeline of students who continue with maths beyond age 16 for advanced mathematical study. |

Figure 1 shows the highest level of attainment in maths by age 19 for students in England: as it was in 1995; as it is today, after decades of progress; and then, as we believe it could be by 2035[21]. Our vision is for almost all students to achieve a standard pass in GCSE Maths, and for a third of students to progress to A-Level Maths or another form of advanced mathematical study.


1995
47
41
5
5
2
Today
18.5
56
11
8.5
6
2035
<5
62.5
12.5
12
8
GCSE Grade 3 or below
A radical reduction in the number of students not achieving this level. Evidence indicates that this could be as low as 3% to 7%.
GCSE grades 4 to 6
A much higher proportion of students achieving a standard pass in GCSE Maths, and continuing with some form of maths beyond age 16.
GCSE grades 7 to 9
More students achieving top grades in GCSE Maths and, if not taking A-Level Maths, continuing with other advanced mathematical study.
A-Level (or equivalent) Grade B or below
More students taking A-Level Maths, as a facilitating subject for a broad range of further study.
A-Level (or equivalent) grades A to A*
More students excelling in A-Level Maths and Further Maths, as preparation for advanced mathematical study.

## Recommendations

Maths Horizons has made seven recommendations, which focus on curriculum, assessment and pathways to further study. Each recommendation defines the scope of a solution that we believe is a "must-have" for a reformed maths education system. Our full report details examples and options for implementation.

| Recommendations 1 to 3 | | |
|---|---|---|
| Curriculum | 1 | **Design a curriculum for mastery** that carefully maps knowledge progression within and between sub-domains of maths. |
| | 2 | **Rebalance content from upper primary to lower secondary**, allowing more time for knowledge to be secured when it is first introduced. |
| | 3 | **Increase the rigour of mathematical reasoning and problem solving for all students**, including specifying more clearly what, when and how students should learn. |

### 1. Design a curriculum for mastery

Over the past decade, England has embraced a "teaching for mastery" approach in maths, which prioritises depth and coherence, with the whole class progressing through the same content at the same time[22]. Yet, while teaching practices have evolved, the current design of the curriculum is holding back learning, as it leads to students often being rushed through the content before they have secured the knowledge.

The unfortunate fact is that too many students are seen as simply being "not good at maths," rather than as learners with less-secure knowledge, which can be identified and addressed. This leads to a damaging cycle in which those most in need of support are given the lowest expectations, the least ambitious teaching, and the fewest opportunities to engage with rich mathematical thinking.

High-performing countries make it a priority to ensure that fundamental knowledge is secure. In Singapore, early number-learning is deliberately limited in scope, but explored in depth[23]. In Japan, careful attention is given to the sequence and representation of concepts[24]. Instead of rushing to cover content, these countries ensure that knowledge is thoroughly secured, so that later learning builds naturally and efficiently.

In England, by contrast, the current design of the curriculum incentivises teachers to rush through content, leading to shaky foundations that can be hard to detect and even harder to rebuild. In our consultations, we heard that, in the absence of specific guidance otherwise, curriculum planning tends to assume that students can be introduced to a mathematical idea, secure the knowledge and then apply it, within a week or two. This compressed timeframe does not reflect how mathematical knowledge is genuinely built.

After the success of teaching for mastery, what England now needs is a "curriculum for mastery", which must bring about a shift in curriculum design and expectations, to emphasise the security of knowledge. This will be painstaking work, but the National Curriculum must do more than list content, it must give a principled account of when and why knowledge should be introduced and developed

In our recommendation to design a curriculum for mastery:

- We recommend specifying the fundamental maths knowledge that students should have secured by critical points in the curriculum.
- We recommend creating knowledge-progression maps within and between sub-domains of maths, and highlighting connections with other subjects.

**2. Rebalance content from upper primary to lower secondary**

The widespread belief among teachers is that the National Curriculum for maths includes too much content; that England has a "crowded curriculum". Our polling found that 82% of primary teachers believe that "the primary maths curriculum has too much content"[25]. This creates pressure on teachers, which can shape their sequencing decisions. In our consultations, we heard that topics are rushed through, knowledge is assumed to be secure, rather than tested for; and too much time is spent on revision-cramming.

Yet the reality is that the National Curriculum for maths – from age 5 to 16 – is comparable, in overall content and taught hours, with high-performing countries. A 2015 TIMSS comparison of taught hours across primary and secondary put England at around the average of OECD countries, and remarkably similar to Singapore[26]. So, the issue is unlikely to be that there is "too much maths to cover", but the way in which the curriculum is sequenced and revisited.

Our mapping found that much of the National Curriculum Key Stage 2 content gets repeated in Key Stage 3. This was captured in our polling too: 74% of secondary students told us that the maths covered in secondary school has repeated things that they learned in primary school.[27]

Key Stage 2 content even shows up in GCSEs, where the topics and level of difficulty can be strikingly similar. A question such as "calculate $4\frac{3}{7} - \frac{5}{21}$" could appear in a Key Stage 2 SAT exam or a GCSE Foundation Tier exam; and, incredibly, while just one mark would be available on the SAT paper, additional method marks would be available on the GCSE paper.

While a large majority of primary teachers believe that the curriculum is too crowded, in our consultations we heard differing views on how to rectify the situation, including calls to remove some more-peripheral content. However, based on our evidence and analysis, we believe that the right solution is to maintain the current curriculum content, which, although broad-based, is comparable with high-performing countries. Instead of removing content, we recommend that it should be rebalanced from upper primary to lower secondary.

Resequencing the curriculum in this way would require changes in how teachers use classroom time. After new content is introduced, more time should be spent developing and securing students' knowledge of it. Across the whole curriculum, the net effect would be to "create more time" for learning, because teachers would not have to waste so much time re-teaching content later. In our consultations, experts told us that international evidence suggests that investing more time up front leads to greater security of knowledge and significantly less need for revision and re-teaching later. Instead, the knowledge could be practised, applied and extended, including through mathematical reasoning and problem-solving activities.

In our recommendation to rebalance content from upper primary to lower secondary:

- We recommend maintaining the same broad-based content of the current National Curriculum, but then rebalancing expectations across upper primary and lower secondary.
- We recommend keeping the current number of taught hours of maths unchanged, noting again that this number is close to the average of other OECD countries.

### 3. Increase the rigour of mathematical reasoning and problem solving for all students

Proof is the heart of maths; its purpose, not a peripheral topic[28]. The ability to engage in proof is built through ongoing practice of mathematical reasoning and problem solving. This is often misunderstood in England, where, rather than increasing the rigour of students' thinking through reasoning and problems, teachers tend to increase the level of challenge by accelerating through content or using larger numbers. This leads to an overemphasis on procedures like written algorithms, often at the expense of reasoning and problem solving. Yet these abilities are central to what it means to learn maths. All students should be supported to develop them, not just those who are doing enrichment activities or preparing for university entrance tests.

The current National Curriculum for maths lists reasoning and problem solving as two of its three core aims, and these are assessed in Key Stage 2 SATs and GCSEs[29]. However, despite being stated aims of the curriculum, reasoning and problem solving are inconsistently and often unsuccessfully embedded in classroom practice. Fewer than half of teachers we polled were confident that 80% of their students could "reason mathematically … at a reasonable standard for their age"[30].

As well as being central to maths education, reasoning and problem solving are highly valued by employers.

In our polling[31], around two-thirds of employers reported that the typical roles in their organisation engage several times per week in "breaking down problems, finding patterns, critical thinking, and strategic planning" (67% of employers) and in "reading, understanding and applying diagrams, graphs, tables, spreadsheets and statistics' (65%). More than two in five employers told us that they would not hire someone if they did not have either of these skills (44%, in the case of both of these skills).

We have identified four issues that hold back students in England from achieving or exceeding the consistently high levels of mathematical reasoning and problem solving that are achieved by students in top-performing countries like Singapore and Japan. (1) An assumption that structured argument and proof are only important for, or achievable by, higher-attaining students; (2) The "crowded curriculum"; (3) The design of assessments, including the incentives created by mark allocations; and (4) The general difficulty of teaching less-routine problems effectively.

Most of these issues could be addressed by improving curriculum and assessment. One priority, as modelled by Singapore and Japan, is to shift from treating problem solving as an "added extra" to making it part of regular teaching practices. Another priority is to create knowledge-progression maps for reasoning, so that problem solving can be deployed as method for securing content knowledge and deepening mathematical learning for all students, not just higher-attaining ones.

We believe that reasoning and problem solving are not separate strands of maths, to be visited in isolation: they are part of what it means to do maths. The curriculum should reflect this truth at every level.

In our recommendation to increase the rigour of mathematical reasoning and problem solving for all students:

- We recommend including reasoning knowledge in knowledge-progression maps, for example: argument patterns, such as contradiction, invariance or working backwards; or re-representations, such as switching a combinatorics puzzle into a diagram.
- We recommend creating examples and questions that demonstrate which "familiar content" should be developed through problem solving, and which types of problem to use.

**Recommendations 1 to 3 in practice**

In our consultations, we heard many calls for a renewed focus on the sub-domains of shape and space, and data and uncertainty. As outlined in Recommendation 2, we concluded that the issue is not the amount of curriculum time allocated to these sub-domains, but how that time is used. Although the curriculum specifies the content that students should learn within these sub-domains, it often neglects the purpose, progression and "habits of thinking" that underpin them, such as spatial reasoning, argument, interpretation and critique. By contrast, in high-performing systems, geometry and data are not isolated content; they go hand-in-hand with the development of reasoning and problem solving through carefully-sequenced tasks.

A curriculum for mastery should prioritise clearer progression and more-purposeful tasks in both sub-domains. In space and shape, it should move beyond naming and properties of shapes and angles, to include composing, transforming, visualising and reasoning. In data and uncertainty, it should move beyond charts and averages, to include planning investigations, interpreting variability and evaluating real-world claims. In both cases, reasoning and problem solving should be taught explicitly, not left to chance. If expectations for reasoning are clearly defined – such as using diagrams, recognising patterns or questioning assumptions – then they can be taught systematically, practised regularly and used to support learning for all students.

| Recommendations 4 to 6 | | |
|---|---|---|
| Assessment | 4 | **Introduce low-stakes gateway checks of fundamental knowledge**, to be administered nationally at specified points in new knowledge-progression maps. |
| | 5 | **Reform the Key Stage 2 SAT exams** to increase the marks required to achieve the "expected standard"; and to rigorously test mental methods and problem solving. |
| | 6 | **Reform the GCSE exams** to ensure that a "standard pass" demonstrates secure fundamental knowledge; to rigorously test problem solving; and to improve the retake system. |

**4. Introduce low-stakes gateway checks of fundamental knowledge**

In our consultations, we heard some appreciation for the way that now-discontinued national assessments – including Key Stage 1 and Key Stage 3 SATs – provided schools with external benchmarks for attainment and progress. Many contributors told us that new classroom assessments could be designed to help teachers and school leaders prioritise appropriately, by providing additional, timely data on how students compare nationally, but without the pressures of high-stakes exams, such as GCSEs.

We believe that it would be helpful to introduce a limited number of low-stakes "gateway checks" to test that students have secured the fundamental knowledge set out in the National Curriculum. These checks should be broad-based, including concepts and methods, as well as facts. These could include checks in Key Stage 1 for number patterns and bonds; and checks in Key Stage 3 for multiplicative and proportional reasoning. These checks should be administered nationally at specified points in new knowledge-progression maps.

A current example of a gateway check is the Multiplication Tables Check, which became statutory in England in 2021. The check is taken by Year 4 students (age 8 or 9). It is taken online, under teacher supervision, and consists of 25 multiplication questions up to 12 x 12, each with a six-second time limit. The argument for the Multiplication Tables Check is that multiplication facts are essential "building blocks" that enable students to perform more-complex mathematical operations; and that the checks encourage teachers to ensure that this knowledge is secure[32].

In our recommendation to introduce low-stakes gateway checks of fundamental knowledge:

- We recommend introducing a limited number of low-stakes gateway checks of fundamental knowledge, to be administered nationally at critical points in new knowledge-progression maps.
- We recommend retaining the current Multiplication Tables Check, but reviewing the impact of its timing and reporting, to ensure that its implementation is optimally supporting students and teachers.

**5. Reform the Key Stage 2 SAT exams**

SATs were introduced in the 1990s to provide a national benchmark for attainment and progress, and a tool for school accountability. Today, the Key Stage 2 Maths SAT is taken by all Year 6 students (age 10 or 11). The exams comprise three written papers: one 30-minute arithmetic paper and two 40-minute reasoning papers that emphasise applying mathematical knowledge to solve contextualized problems.

In 1995, only 45% of students achieved at least a Level 4 in the Key Stage 2 Maths SAT (a grade deemed to show readiness for secondary maths). This rose to around 80% of students by 2015[33], after which the grading system was changed to an "expected standard" measure. While the newer expected standard is achieved by around 75% of students today, the threshold suggests that the assessment may not be aligned appropriately with the curriculum. In 2024, the cumulative score required to achieve the expected standard was 54 out of 110 across the three papers; fewer than half of the marks[34].

For two decades, Year 6 students, took an audio mental maths exam, along with two written papers. In 2016, this mental maths component was replaced by a written arithmetic paper, which focuses on the methodical execution of standard algorithms. The written arithmetic paper currently accounts for 40 of the available 110 marks. With proportionally fewer marks available on other papers, the corollary is that students receive fewer marks for demonstrating agility in areas such as benchmark fractions, part–whole relationships and order of magnitude estimation.

In our consultations, we heard that many respondents see the fastest route to achieving expected standards in the Key Stage 2 Maths SATs is to maximise marks on the arithmetic paper. Schools therefore tend to devote significant curriculum time to practising these calculations, usually at the expense of other areas of maths. As a result, Year 6 often becomes a rehearsal year, in which mathematical reasoning and problem solving are squeezed out by repetitive practice of mechanical approaches to maths, with "drilling" often beginning as early as the January before the summer exams.

In our recommendation to reform the Key Stage 2 SAT exams:

- We recommend maintaining the current difficulty level, but increasing the marks required to achieve the expected standard from its current level of 50% to 75%, which would better demonstrate comprehensive fundamental knowledge.
- We recommend increasing the proportion of marks allocated to mental methods and problem solving, which are currently under-valued relative to written arithmetic.

**6. Reform the GCSE exams**

GCSE Maths holds a powerful position in England's education system, including as a springboard to further study and work. Today, GCSE Maths is taken by almost all students at age 16. The exams comprise one non-calculator paper and two calculator papers. Students can enter in either Foundation Tier exams (enabling grades 1 to 5) or Higher Tier exams (enabling grades 4 to 9). Most students who do not achieve a Grade 4 will continue to retake GCSE Maths until they do so, or until they reach age 19.

In 1995, only 53% of students had achieved what was then called a "good GCSE pass" (Grade C) by age 19. Today, around 80% of students achieve the equivalent standard, now called a "standard pass" (Grade 4). However, the current grading system may not signal mathematical competence in a way that universities and employers might reasonably expect it to. In 2024, a student taking the Foundation Tier could score 44% and achieve a Grade 4; and a student taking the Higher Tier could score 14% and achieve a Grade 4.

GCSE Maths is not currently meeting the needs of students. Generally speaking, the structure of the exams incentivises teachers to focus on memorising tips and tricks, instead of building fundamental knowledge. This does a disservice to all students, from those who struggle to those who excel.

Despite retakes being compulsory for students who do not achieve a standard pass at age 16, around 20% of all students still do not achieve one by age 19, after an estimated 1,600 hours of maths. We believe that, with the right support, these students can succeed, and that they are owed a better experience of the retake system. Too many students are being rushed into early exam retakes, which reduces the chance of genuinely addressing insecure knowledge. The experience of repeatedly retaking the same papers can be dispiriting, especially since there is a very low success-rate for students who achieved a Grade 2 or below at age 16.

In our consultations, we heard various suggestions to these issues, including that the above problems could be fixed by splitting GCSE Maths into a more-academic "pure" paper and a more-applied, "numeracy" paper. However, evidence cautions against this. In England, a 2010 pilot that split maths exams into methods and applications found several problems, including that teaching time became fractured, and that most schools entered students for only one paper, which led to "social sorting" and less value being put on the numeracy paper. In Wales, the 2015 policy to split exams into Mathematics and Mathematics-Numeracy faced similar problems, with universities largely ignoring the numeracy grade. Following these disappointing outcomes, the policy will be replaced in 2025 by a single exam worth two GCSEs.

Based on our evidence and analysis, we believe that the right approach is to maintain a single GCSE in maths. The current single GCSE, in which students can already access Foundation and Higher tiers, retains shared core-content, and around 20% of overlapping questions, allowing all students to pursue the same qualification, while also providing appropriate stretch. Reintroducing parallel qualifications would almost certainly widen socio-economic gaps and face the same fate as the system in Wales and the failed pilot in England.

In our recommendation to reform the GCSE Maths exams:

- We recommend that a "standard pass" needs to demonstrate secure fundamental knowledge and that this should be achieved through the introduction of a gateway paper for all students. This paper should have a high pass mark and test a broad range of fundamentals.
- We recommend increasing the proportion of marks allocated to reasoning and problem solving, which are currently under-valued relative to recall and routine application.
- We recommend that students should first retake the gateway paper if they are not successful, securing the fundamental knowledge. They should then retake the rest of the papers after, with a gateway paper pass being portable across retake sessions to avoid redoing it. This will reduce the volume of resits.

| Recommendation 7 | | |
|---|---|---|
| Pathways | 7 | **Explore a maths entitlement for 16- to 19-year-olds**, which should aim to promote take-up of Core Maths; to review the content of A-Level Maths; and to pilot a standalone A-Level Further Maths course. |

### 7. Explore a maths entitlement for 16- to 19-year-olds

Many advanced economies, including Canada, France and Germany, and Shanghai in China, require students to continue with maths until age 19[34]. Unlike many peer countries, students in England can stop studying maths at age 16 and so, for most, their journey ends there. However, there is public appetite for this to change, with one survey by Axiom Maths finding 72% of respondents in favour of making "maths to 18" compulsory[35].

In 2023, 14.5% of all 19-year-olds in England achieved what we are calling "advanced mathematical study". The vast majority of these students took A-Level Maths (11.1% of all 19-year-olds), with the rest taking courses including Core Maths (1.9%), AS-Level Maths (1.3%) and the International Baccalaureate (0.3%)[36]. While this is a good start, our ambitious vision is for a third of students to progress to A-Level Maths or another form of advanced mathematical study.

Given that 71% of 16-year-olds achieved at least a Grade 4 in GCSE Maths in 2023, and only 14.5% continued to advanced mathematical study, this means that 54% of students are dropping maths at age 16[37]. For many of these students, a ready-made solution is the Core Maths Level 3 qualification, which emphasises real-world maths, such as data analysis, modelling and risk. First introduced in 2014, entries for Core Maths have grown from 3,000 in 2016 to 12,000 in 2023[38], and it is increasingly recognised by universities and employers. Yet, despite the government offering schools up to £900 per student to encourage take-up, still only around 30% of sixth-forms and colleges offer the course.

Maths is now the most chosen A-Level course, with more than 100,000 entries in 2024.In our consultations, we heard varied opinions about the content of A-Level Maths, with some calling for more statistics and data handling, and others for more problem-solving and proofs. Several respondents noted that some important topics have insufficient marks allocated in exams, and that the questions can be too superficial. For example, one person noted: "The large data set is a valuable element of the course, but … as the exams do not require students to manipulate the data as you would do a large data set, all the questions can be answered with common sense and require very little knowledge or understanding of the data set."

There has also been a large increase in A-Level Further Maths entries, from 5,000 in 1995 to 18,000 in 2024[39]. However, in our consultations, many teachers were concerned that A-Level Further Maths gets "crowded out", as some schools only allow students to take three A-Level courses, and Maths and Further Maths take two of the slots. We heard that this particularly discourages girls from taking A-Level Further Maths, since they are more likely to prefer taking a breadth of courses. We also heard worries that some schools are unable to offer A-Level Further Maths. While provision of the course in state-funded institutions has increased from around 40% in 2005 to around 75% in 2024[40], there is still more work to do.

We recommend that the government explores a maths entitlement for 16- to 19-year-olds, which would not make it compulsory to continue with maths until age 19, but would encourage and support students to do so, whether through A-Levels, Core Maths, vocational pathways or GCSE retakes.

In our recommendation to explore a maths entitlement for 16- to 19-year-olds, this should aim:

- To promote take-up of Core Maths, building the capacity of all sixth forms and colleges to offer the course.
- To review the content of A-Level Maths, reflecting on how effectively the 2017 curriculum reforms are working, including the exam marks allocated to data handling, problem solving and proof.
- To pilot a standalone A-Level Further Maths course, which it should be possible to deliver within a single, augmented A-Level slot. Such a qualification would include the A-Level Maths content, and students would progress at a faster pace through the material. One option could include requiring more study hours for this than for the current A-Level Maths course, although the feasibility of this needs to be tested.

## Moving forward

Maths Horizons believes that England can and should aspire to be one of the top-performing countries in the world for maths. Our vision is to raise standards at every level, so that almost all students leave education having achieved at least a standard pass in GCSE Maths, and that there is a significant increase in the number of students who continue with maths beyond age 16 for advanced mathematical study.

To help make this vision concrete, this report sets out three objectives and makes seven recommendations.

We believe that, if the education system can align around high expectations, these objectives are achievable within the next decade. We believe that our recommendations can be implemented quickly and effectively, provided that there is purposeful action from the government, and support from a range of stakeholders.

In the months ahead, we will continue to undertake detailed analysis to support curriculum and assessment design, and on-going engagement across education, academia and industry. In particular, we will focus on the following priorities: preparing to develop a curriculum for mastery, with appropriate sequencing; developing knowledge-progression maps and example questions, including for problem solving; and investigating how gateway checks could be introduced and exams reformed.

Beyond these priorities, we have also identified some important new strands of work, which touch on wider issues within the education system, and which we will begin in the months ahead:

- To exemplify connections across the curriculum, we will explore how non-statutory guidance could be developed to include examples of how topics link together, both within sub-domains of maths and with other subjects, and to list essential terms with oracy prompts.
- To support students' use of technology in maths, we will explore how the curriculum could specify what digital tools should be encountered at each key stage, potentially including deterministic technologies at primary-level and AI-assisted tools at secondary-level.
- To improve the impact that exams have on the way that students are taught maths, we will explore ways in which the design and regulation of exams could place more weight on assessing problem solving, and could potentially introduce pilots for screen-based exams.

We look forward to developing a shared vision for England to be one of the top-performing countries in the world for maths. Alongside our work on Maths Horizons, which is focused on curriculum and assessment, we are excited to be part of a wider coalition that is working on other crucial issues in maths education, including areas such as public attitudes to maths, the teacher workforce, and AI and ed tech.

## Appendix

### About Maths Horizons

Maths Horizons is chaired by Prof Lord Lionel Tarassenko, President of Reuben College, Oxford. It is co-led by Dr Helen Drury and David Monis-Weston, both former maths teachers and education charity founders.

They are supported in their work by an Executive Group of advisors, which includes teachers, leaders and experts from primary, secondary and further education, and representatives from academia and industry.

| Maths Horizons Executive Group | |
|---|---|
| Prof Lord Lionel Tarassenko CBE | President, Reuben College, University of Oxford |
| Dr Helen Drury | Dean of Maths Education, Purposeful Ventures; Founder, Maths Mastery (Ark) |
| David Monis-Weston | AI Lead, Purposeful Ventures; Founder, Teacher Development Trust |
| Shahed Ahmed OBE | CEO, New Vision Trust |
| Peter Foulds | Maths School Improvement Advisor, Lingfield Education Trust |
| Prof Camilla Gilmore | Professor of Mathematical Cognition, Loughborough University |
| Prof Catherine Hobbs | Professor of Mathematics, University of Bristol |
| Dr Asyia Kazmi OBE | Global Education Policy Lead, Gates Foundation |
| Matt Ley | Director of Design Engineering, Rolls-Royce |
| Dr Angie Ma | Co-Founder, Faculty |
| Lisa Pollard | Director of Education, Palladian Academy Trust |
| Sarah Waite | Founder and CEO, Get Further |
| Prof Anne Watson | Emeritus Professor of Mathematics Education, University of Oxford |

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