Maths Horizons

How England should reform maths education for the age of AI

Full Report

May 2025

MATHS HORIZONS

Contents

1. Foreword

The development of artificial intelligence (AI), initiated by a paper written by the British mathematician Alan Turing 75 years ago[1], has now reached such a stage that most maths problems which students will attempt during their schooldays can be solved by AI models known as large language models (LLMs)[2]. Paradoxically, this makes the teaching of maths in England's schools more important than ever. It must include training the most able mathematicians, so that they can help to develop the AI models of the future and understand how to design appropriate guardrails for them. But it must also include ensuring that every student learns enough maths so that they can validate and interpret the outputs from the AI algorithms running on their phones.

This in-depth review of maths curriculum and assessment in England, Maths Horizons, is therefore very timely. It has been a pleasure to chair the project, working with two exceptional co-leads, Dr Helen Drury and David Monis-Weston. The project has been supported by an Executive Group, including a brilliant array of maths education experts, augmented by two industry experts, from Faculty AI and Rolls-Royce.

Maths Horizons was conceived and conducted as a rapid review, timed to run in parallel with the Department for Education's Curriculum and Assessment Review, led by Prof Becky Francis, and to inform their work. We started in September 2024, with an evidence-gathering phase involving large-scale polling of representative samples of over 10,000 teachers, 2,000 parents, 2,100 students, 2,200 employers and 2,000 employees. Building on this polling and our wider consultations, we began to identify key issues, which were outlined in an Interim Report in February 2025[3].

Maths Horizons' vision is for England to become one of the top-performing countries in the world for maths, with almost all students securing a "standard pass" in GCSE Maths, and with a third of students progressing to A-Level Maths or another form of advanced mathematical study, such as Core Maths. Academic research and evidence from top-performing countries show that is possible to achieve this vision.

This final report proposes three objectives and seven recommendations, which offer a blueprint to reform maths education in the age of AI. We believe that each recommendation can be implemented reasonably quickly, without requiring huge resources. The report also highlights further priorities for research and policy development, such as how to build students' familiarity with digital tools for maths, including AI models.

Maths Horizons is ambitious for England's future, and we believe that the adoption of our evidence-based recommendations would enable every young person in England to master maths and help them to thrive in the digital world of tomorrow.

L. Tarassenko

Professor Lord Tarassenko CBE FREng FMedSci

2. Executive Summary

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 employers telling us that they expect maths skills to become more important over the next two years[4]. England's future success will rely heavily on maths education.

Over the past few decades, successive governments have undertaken a programme of reforms 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[5]. More students than ever achieve a "standard pass" in GCSE Maths by the age of 19, the rate having increased from 53% in 1995[6] to around 80% today[7]. Maths is now the most chosen A-Level, with more than 100,000 entries in 2024[8].

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[9].

More should be done to support students to progress in maths beyond the age of 16. Despite retakes being compulsory for students who do not achieve a standard pass at 16, around 20% of all students still do not achieve one by 19, after an estimated 1,600 hours of maths[10]. At the other end of the spectrum, too few of the students who gain a standard pass in GCSE Maths progress to advanced mathematical study, which we define as A-Level Maths, A-Level Further Maths, Core Maths and International Baccalaureate 16-19 Maths.

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 the age of 16.

To deliver on this vision, this report sets out three objectives and makes seven recommendations. We believe that, if the education system is configured to meet high expectations, these objectives are achievable within a 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, with ongoing 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.

3. The Case for Reform

3.1 Maths education in the age of AI

At the start of 2023, ChatGPT was able to achieve a standard pass in GCSE Maths[11]. At the start of 2024, the AI Mathematical Olympiad Prize was launched[12]; 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 state-of-the-art AI models can now solve most problems that are equal in difficulty to those tackled by the top 0.1% of 17-year-olds in national maths competitions[13].

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 rely too heavily on symbolic representation. This 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 answers. Maths knowledge is needed to spot subtle errors and hallucinations in replies, and to refine prompts to achieve better answers. A society that is fluent in maths will be able to scrutinise the algorithms that increasingly govern public life, instead of surrendering decision-making to them.

The Government's National AI Strategy notes that England's strength in AI has been built on its maths and computing expertise[14]. The Royal Society argues that exponential growth of data and analytical power is transforming every sector, increasing the need for advanced mathematical skills[15]. Data specialist businesses contribute 7.4% of UK GDP, the second largest proportion of any country in Europe, and this remains a significant growth opportunity. Many of the country's most profitable new companies have a deep focus on maths.

However, England's education system is at risk of not keeping up with labour market needs. Maths Horizons polling found that many companies – especially "frontier tech" companies – place great value on maths, with 78% of frontier tech employers telling us that they expect maths skills to become more important over the next two years[16]. In particular, they value the critical thinking skills that are associated with mathematical reasoning. As one tech founder put it: "The ability to think critically and interpret data, and what it physically means and tells us, [is] increasingly important."

The biggest gap between what frontier tech companies tell us they need and what students are taught is "breaking down problems, finding patterns, critical thinking and strategic planning". The need for these skills is likely to increase in the coming years, and the most successful students will be those who can continually adapt to new developments in AI. Given that data science techniques can quickly become obsolete, the best preparation for students will often be to have strong foundations in "pure maths" – topics like number theory, geometry and algebra – and well-practised problem-solving skills.

In our consultations, we heard repeatedly that mathematical reasoning and problem solving are important for everyone, not just future engineers, scientists or technologists. All of us can benefit from seeing the world in terms of mathematical models that we can understand and apply, whether this is conducting a negotiation, making an investment, or solving a puzzle. Reasoning and problem solving equip people to think critically and make informed decisions, even when calculators or LLMs are not readily at hand.

3.2 Where we are now

Decades of progress

Over the past few decades, successive governments have undertaken programmes of reform to strengthen maths education in England. The National Curriculum in 1988[17] and the National Numeracy Strategy in 1999[18], ushered in a standards-driven approach to maths teaching, which emphasised numeracy, mental arithmetic and regular national assessments. These changes significantly increased school accountability for outcomes and were followed by sustained improvements in exam results.

Subsequent National Curriculum reforms in 2014[19] drove up rigour further, setting age-related expectations at primary-level, and increasing the difficulty of content in GCSEs and A-Levels at secondary-level. Around this time, the Maths Hubs programme[20] created 40 regional centres of excellence to spread the "teaching for mastery" approach[21] (Figure 1). The programme offers professional development for primary and secondary teachers, and included exchange visits with Shanghai, a top-performing education system and one of the inspirations behind teaching for mastery.

Overall, students in England perform better in maths than ever before. The Trends in International Mathematics and Science Study (TIMSS) in 2023 showed that, despite the Covid pandemic, England's Year 5 maths results remained stable and its Year 9 maths results improved significantly[22]. Against a backdrop of falling results elsewhere, England ranked as one of the top-performing countries in maths outside East Asia.

Although it is commonly assumed otherwise, most students have a positive view of maths. Our polling found that 67% of students consider maths to be "the most helpful subject for their future", and that 67% of primary students and 50% of secondary students say that they "enjoy maths"[23].

Another positive trend is that more students than ever leave education having attained a "standard pass" (Grade 4 or above) in GCSE Maths by the age of 19. The rate has increased from 53% in 1995[24] to around 80% today[25]. Since the introduction of compulsory GCSE Maths retakes in 2013, more than 400,000 students who did not achieve a standard pass in GCSE Maths or English at age 16 have gone on to achieve one by age 19[26]. The impact of this policy is now feeding through into adult numeracy levels, which OECD data shows have been rising since 2012, driven by improvements among 16- to 24-year-olds and 25- to 34-year-olds[27].

There has also been impressive growth in take-up of A-Level Maths, which is now the most chosen A-Level course[28]. A new record was set in 2024, with over 100,000 A-Level Maths entries in England, representing over half of all students that took A-Levels[29]. Another record was also set in 2024 for A-Level Further Maths entries, with over 18,000 students in England taking the course[30].

Figure 1 Teaching for mastery

The central idea of teaching for mastery is that all students can and should acquire secure knowledge of the maths they are learning, so that future learning is built on solid foundations, which do not need to be retaught[31]. Students move together through the same curriculum, without the need for separate "streams" or catch-up programmes. Lessons are designed so that students learn knowledge securely and practise using it, while teachers identify and address gaps in learning. As well as memorising facts and procedures, and answering questions quickly and accurately, students are expected to use knowledge appropriately and flexibly, and to apply it in new and unfamiliar situations. The teaching for mastery approach has strong evidence of impact, including randomised control trials run by the Education Endowment Foundation[32].

Persistent challenges

The experience of the last few decades shows that ambitious change is possible. When the education system is configured to meet high expectations, substantial improvements can be achieved for millions of students. However, despite all the good news, too many students still struggle with maths, and many more students could progress to advanced mathematical study at age 16. Therefore, if England is to thrive in the age of AI, it must overcome some persistent challenges.

Although England ranked highly in TIMSS 2023, the data[33] highlighted worrying trends for maths education, including: weaker national performance in mathematical reasoning, geometry and algebra; an increasing gap between lower- and higher-attaining students; and continuing socio-economic and gender disparities, with girls consistently underperforming boys in many areas of maths.

One major problem that we heard in our consultations is that teachers widely believe that there is a "crowded curriculum" with "too much maths to cover". Consequently, students are rushed through content, without securing knowledge thoroughly, which leads to reteaching of the same content later. The lower secondary curriculum repeats too much content from upper primary, which was not secured first time round.

While dispiriting for most students, this is a particular issue for high-attaining students, among whom there is a surge in reporting that maths is "boring" and "too easy"[34] once they reach Key Stage 3. It is perhaps not surprising, then, that 35% of students who rank in the top quintile in Key Stage 2 Maths SATs "drop off" by age 16, and do not achieve a Grade 7 or above in GCSE Maths.[35]

These problems are compounded by an assessment system in which national exams are not comprehensively testing for fundamental knowledge. In Key Stage 2 Maths SATs, students who achieve half marks are deemed to have met the "expected standard"[36]. At GCSE-level, students can achieve a standard pass in the Higher Tier GCSE Maths exam by obtaining as little as 14% of the available marks[37].

Despite retakes being compulsory for students who do not achieve a standard pass in GCSE Maths at age 16, around 20% of all students still do not achieve one by age 19. For many, this is after 15 years of study and an estimated 1,600 hours of maths lessons[38]. Notably, students who do not achieve a standard pass in both GCSE English and Maths are disproportionately from low-income backgrounds (43% of this group) and/or have special educational needs or disabilities (59% of this group).[39]

At the other end of the spectrum, the problem is that too few students progress to advanced mathematical study. Unlike in many peer countries, in England it is not mandatory to study maths beyond age 16 and so, for most students, their journey ends there. Many students who achieve high marks in GCSE Maths do not take A-Level Maths, with an especially sharp drop-off among girls, of whom only 12.4% take A-Level Maths, compared with 22.4% of boys[40].

Looking beyond the school system, take-up of maths degrees has not kept pace with the increase in A-Level Maths entries. Over the past decade, maths has been gradually losing its undergraduate "market share", with the proportion of total first-year first-degree enrolments in maths falling from 3.4% in 2012 to 2.9% in 2021[41].

3.3 Vision for the future

Exemplary performance

Cognitive science research and real-world data from the highest-performing education systems indicate that at least 90% of students could achieve a standard pass in GCSE Maths. Research shows that maths learning difficulties, such as dyscalculia, affect only 3% to 7% of students[42], far fewer than the 21% who did not achieve a standard pass in GCSE Maths by age 19 in 2024[43]. 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[44]; and from Singapore, where 41% of students are classed as "top performers" in maths in PISA 2022 (UK: 12%; OECD average: 9%)[45].

If England could match the performance of the Netherlands, around 60,000 more students each year would achieve a standard pass in GCSE Maths, unlocking significant opportunities for further study and work[46]. More ambitiously, if England could match the performance of Singapore, around 170,000 more students each year would achieve grades 8 or 9 in GCSE Maths[47], supporting progress to advanced mathematical study.

England is starting from a strong position. Its strong overall performance in international comparisons tends to be driven by doing better on questions that require recall of facts and procedures, rather than application of knowledge or reasoning, as shown in TIMSS 2023. However, in the same study, Singapore ranked highest in the "knowing" domain of maths, as well as in the "applying" and "reasoning" domains, showing that there does not need to be a trade-off between learning maths knowledge and applying it; both can be achieved simultaneously[48].

Leaving other countries to one side, even just closing England's attainment gaps would yield major returns. If England could support students who are eligible for free school meals to achieve Grade 7 or above in GCSE Maths at the same rate as students who are not eligible, the knock-on effect would be around 30,000 more students taking A-Level Maths each year[49]. Likewise, if girls could be supported to take A-Level Maths at the same rate as boys, this would result in around 28,000 more students each year[50].

While there are good reasons to believe that standards can be raised further in England, many teachers may underestimate the potential of their students to achieve a standard pass in GCSE Maths. Our polling found that, in schools serving the most deprived students, 40% of teachers think that at least 20% of their students are not capable of achieving a standard pass by age 19[51]. This mindset must change if England is to achieve outstanding results for all students.

Vision for 2035

Our vision is for almost all students to achieve a standard pass in GCSE Maths, and for a third of students to achieve at least a Grade 7 in GCSE Maths and progress to advanced mathematical study. 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. Figure 2, below, 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; then, as we believe it could be by 2035[52].

4. Recommendations

To help realise Maths Horizons' vision to reform maths education for the age of AI, this report sets out three objectives and seven recommendations. We believe that, if there is purposeful action from the Government, and support from a range of stakeholders, the recommendations can be implemented quickly and effectively, and the objectives are achievable in the next decade.

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.

Each recommendation defines the scope of a solution that we believe is a "must-have" for a reformed maths education system. In some instances, we have summarised some high-level options for a solution, including criteria against which to assess them. Where appropriate, we give a favoured option; elsewhere we remain open, as further work will be needed before making a choice.

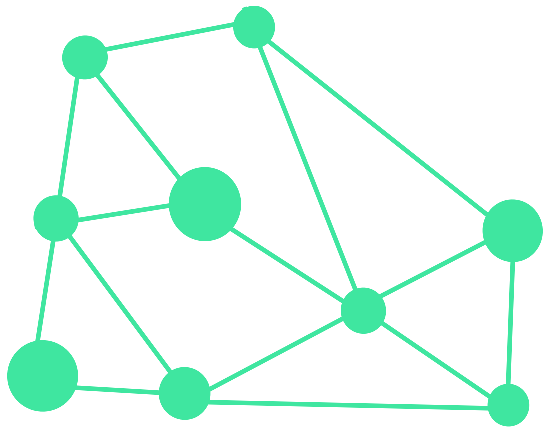
4.1 Design a curriculum for mastery

Recommendation 1	
1	**Design a curriculum for mastery** that carefully maps knowledge progression within and between sub-domains of maths.

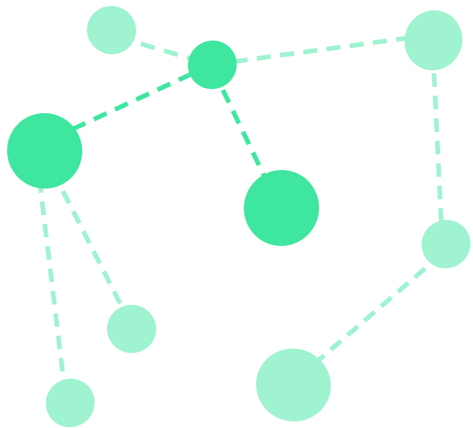
We define "maths knowledge" broadly, to encompass concepts, facts and methods. Maths knowledge is hierarchical in nature. This is not to say that the domain of maths has one linear hierarchy of knowledge. Rather, it can be thought of as something like a lattice-structure, comprising different sub-domains, such as algebra, geometry and statistics. "Depth" describes the quantity of secure knowledge within a sub-domain, and the strength of connections between that knowledge.

Having secure knowledge is essential for future maths learning. To be considered "secure", knowledge must be retrievable and applicable with confidence, automaticity and accuracy. This enables students to progress as they build depth, breadth and connections.

When students have **secure knowledge** they have solid foundations and strong connections



When students have **insecure knowledge,** new topics are disconnected and hard to remember



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[53]. Yet, while teaching practices have evolved, the current design of the curriculum is holding back learning, as it too often leads to students being rushed through the content before they have secured the knowledge.

As a result, students have less knowledge, and that which they have is less secure. In our consultations, experts told us that this surfaces as anxiety, confusion, disengagement or under-attainment. In its 2023 review of maths teaching in England, Ofsted repeatedly cited the problem of knowledge "gaps", which exist at all stages[54].

- In Key Stage 1: "Practitioners were responsive to children's needs, but there was little evidence that they were systematically addressing gaps in the children's mathematical knowledge."
- In Key Stage 2: "In [some] lessons, teachers moved on to new content while significant numbers of pupils had gaps in their knowledge or a lack of automaticity that would limit their chances of successfully learning new mathematics."
- At GCSE: "In many schools, little attention was paid to identifying gaps in pupil knowledge and effectively addressing them … [which] results in many pupils moving to the next stage of their learning with significant gaps in their mathematical knowledge."

The following example shows how these kinds of knowledge gaps can arise:

Example: A tension between universal methods and depth of knowledge

In the run-up to national assessments, teaching often prioritises quick-win methods that secure marks, even when they bypass depth of knowledge. One common example is the shortcut for dividing fractions – "keep, change, flip" – where, for instance, $\frac{5}{6} \div \frac{7}{8}$ becomes $\frac{5}{6} \times \frac{8}{7}$. While this reliably produces the correct answer, it encourages mechanical application without understanding, reducing maths to memorising and reproducing methods. Teachers note the appeal of this method lies in its universality, including for simpler cases, such as $\frac{1}{3} \div 2$. But here too, students often follow the steps – rewriting 2 as $\frac{2}{1}$, flipping it to $\frac{1}{2}$, and multiplying – without seeing the meaning of the question (e.g. "what is half of a third?"). This approach supports short-term performance, but risks undermining the depth of knowledge and mathematical reasoning that are needed for long-term success.

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.

When teachers have low expectations of students, it negatively impacts student attainment[55]. Teachers often adjust their practice accordingly; narrowing the content, lowering the challenge or steering students towards procedural shortcuts. This is not always done intentionally by teachers, it can be a reflexive strategy that arises from repeated experience of students appearing to struggle with "the basics". Without a shared benchmark for what secure knowledge looks like, teachers make their own judgments, which can conflate when students are encountering genuine difficulty (e.g. cognitive load) with when they are anxious or disengaged.

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, allowing all students to develop secure knowledge of place value, calculation and proportional reasoning[56]. In Japan, careful attention is given to the sequence and representation of key concepts, with entire lessons built around securing knowledge of a single concept[57]. 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; all within a week or two. This compressed timeframe does not reflect how mathematical knowledge is genuinely built. In practice, this leads to unrealistic expectations: some students are able to secure the knowledge quickly, while others get left behind, and often never progress beyond the initial introduction stage.

Without a shift in curriculum design and expectations to emphasise the security of knowledge, the potential of teaching for mastery will not be fulfilled. To truly teach for mastery, it must be recognised that introducing, developing and securing knowledge is a process that unfolds over time, requiring repeated encounters, varied practice, and opportunities for application and reasoning.

Recommendation 1

1	**Design a curriculum for mastery** that carefully maps knowledge progression within and between sub-domains of maths.

After the success of teaching for mastery, England now needs 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.

A curriculum for mastery should focus on learning trajectories, not coverage targets. It should support teachers to identify what secure knowledge looks like at each stage and provide clear criteria for when students are ready to move on. This would also help to align assessment with teaching and reduce the pressure to superficially "teach for the test".

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.

4.2 Rebalance content from upper primary to lower secondary

Recommendation 2	
2	**Rebalance content from upper primary to lower secondary**, allowing more time for knowledge to be secured when it is first introduced.

The "crowded curriculum"

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"[58]. 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.

The current curriculum structure requires the introduction of a substantial volume of new mathematical content each year. This places significant pressure on teachers to prioritise content coverage over conceptual depth and coherence. As a result, topics are often taught in isolation, with limited opportunity to explore meaningful connections between ideas. For example, in Year 4, topics such as coordinates and symmetry are typically addressed separately, despite their potential for integration[59]. The demands of pacing and progression mean that teachers seeking to avoid cognitive overload for students are left with little choice but to compartmentalise learning. This fragmentation leads to a disjointed experience for learners and undermines opportunities to develop a connected, secure understanding of mathematics.

Ofsted highlights the downstream effects of this kind of shallow initial teaching: "Pupils who are learning more slowly than their peers frequently receive a maths education that does not meet their needs. They are often rushed through the study of new content, in order to 'complete the course', without securely learning what they are studying […] Often the curriculum for these pupils is narrowed with little teaching of how the facts and methods learned can be used to solve problems mathematically. Many of these pupils develop a negative view of maths."[60]

Yet the reality is that the National Curriculum for maths – from ages five to 16 – is comparable, in total content and taught hours, with high-performing countries. A TIMSS 2015 comparison of taught hours across primary and secondary, put England at around the average of OECD countries and remarkably similar to Singapore[61]. 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.

While a large majority of primary teachers believe that the curriculum is too crowded, our analysis shows that this is caused by curriculum design choices that lead to shallow learning of content in upper primary, which leads to reteaching in lower secondary[62]. Our mapping of the National Curriculum finds that much of the Key Stage 2 content is repeated in Key Stage 3. Examples include: identifying prime or square numbers from a list; working out the percentage of a large rectangle that is shaded; calculating amounts spent, or change to be given; and calculating with fractions.

The Education Endowment Foundation also notes that a lot of Key Stage 3 teaching focuses on revisiting content from earlier years, often because students have insecure knowledge of it[63]. This was captured in our polling too: 74% of secondary students said that the maths covered in secondary school has repeated things that they learned in primary school[64].

Key Stage 2 content even shows up in GCSEs, where the topics and level of difficulty can be strikingly similar. A question such as $4\frac{3}{7} - \frac{5}{21}$ 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.

This has a detrimental effect on progression in Key Stage 3. These are the years when students should be consolidating and extending their grasp of fundamental ideas. However, those who struggled at primary are too often presented with overly simplified work or isolated revision tasks, and higher-attaining students are too often deprived of novelty, challenge and stretch[65].

Rebalancing not removing content

While primary teachers believe that the curriculum is too crowded, in our consultations we heard differing views on how to rectify this, 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 is comparable with other high-performing countries. Instead of removing content from the curriculum, we recommend that it should be rebalanced from upper primary to lower secondary.

The Foundation Tier GCSE Maths specification[66] requires that all students are taught and assessed across a broad mathematical domain, including algebra, geometry, number, proportion and statistics. Internationally, high-performing countries maintain a similar breadth for all students from 14 to 16. Our analysis found that much of the overall content of the National Curriculum does overlap with those countries; the difference in England is that more topics are introduced in earlier years and repeatedly revisited, rather than time and space being given to them when first taught.

In our vision for maths education in England, we believe that almost all students can achieve a standard pass in GCSE Maths. Therefore, the Key Stage 4 curriculum must include algebraic and geometric topics such as factorising quadratics, representing inequalities, and using standard form. Removing this content would risk narrowing students' options for further study and work and set a lower bar for success than top-performing countries in maths.

In our consultations, some contributors argued that the best way to fix the crowded curriculum and create more time would be to remove content, such as Roman numerals (primary) and constructions (secondary). However, even if one believes that these are peripheral items, and of limited use for later learning, commonly used schemes of work on these topics take only two or three lessons. Removing them would make a minimal contribution to reducing the experience of overload, and there are simply not enough peripheral items to create sufficient time, without undercutting the current level of breadth.

Other contributors advised moving away from teaching for mastery, towards students having personalised learning pathways. While the idea of every student progressing through the curriculum at their own pace may sound attractive, it would be likely to widen attainment gaps. When a class progresses at a similar rate, they have many opportunities to hear the teacher explain a topic, to watch solutions, to discuss with peers, or to hear group feedback. However, if all students are progressing at different rates, even studying different topics, most of these benefits are lost. While education technology may eventually help to facilitate some technical aspects of personalised learning, recent evidence shows that current systems are not advanced enough to provide the quality of instruction nor the emotional connection that humans can[67].

Countries like Singapore and Japan do not rush to cover content, they ensure that knowledge is secured thoroughly, so that later learning builds naturally and efficiently. Following their lead, instead of removing content from the curriculum, we recommend that some content should be rebalanced, especially from upper primary to lower secondary.

Our view is that the curriculum should be re-sequenced across key stages 1 to 4. This should have a particular focus on moving content from upper primary to lower secondary. Figure 3 gives an overview of what this could look like. All of this work should build on the NCETM's work on curriculum prioritisation and sequencing.

Resequencing the curriculum in this way would change for the better how teachers use their classroom time. After new content is introduced, more time should be spent developing students' knowledge and ensuring that it is secure. Although students would cover content more slowly, it is a case of "the tortoise and the hare". 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 reteaching content later.

In our consultations, experts told us that international evidence suggests that investing more time upfront leads to greater security of knowledge, and significantly less need for revision and reteaching later. Instead, the knowledge could be practised, applied and extended, including through mathematical reasoning and problem-solving activities.

As well as the above changes to rebalance the curriculum, we recommend that the number of hours of maths teaching remains unchanged, noting again that this number is close to the average of other OECD countries. While the government may face calls to reduce the number of taught hours of maths, we oppose this policy, which would negate and outweigh the benefit of rebalancing curriculum expectations.

Recommendation 2	
2	**Rebalance content from upper primary to lower secondary**, allowing more time for knowledge to be secured when it is first introduced.

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, particularly across upper primary and lower secondary.
- We recommend keeping the number of taught hours of maths unchanged.

We recommend that any solution should satisfy the following criteria:

- Sufficient time for almost all students to achieve secure knowledge of the content.
- Explicit mapping of where earlier content will be revisited.
- No reduction in the ambition or overall amount of curriculum content from ages five to 16.
- A universal curriculum, with minimal additional content for higher-attaining students at ages 14 to 16.

Example approach

In our consultations, one suggestion that we heard was to remove all content except fundamental number knowledge from Key Stage 1, and to delay the teaching of time, shape, fractions and data until Key Stage 2. This would increase the likelihood that students secure the fundamental number knowledge. However, we found insufficient evidence about the consequences of delaying the teaching of time, shape, fractions and data. Therefore, the risk is that such a change may reduce curriculum ambition by the end of Key Stage 4.

Our favoured option is to move a selection of content from Key Stage 2 to Key Stage 3, including for example: algebraic expressions, co-ordinates, fraction calculations and negative numbers. This would allow more time in upper primary to secure fundamental number knowledge, and preserve the ambition and breadth of the curriculum by the end of Key Stage 4. Figure 3 outlines an example approach, showing where current Year 6 content (highlighted in bold) could be moved for first teaching to years 7 and 8.

Figure 3 Current Year 6 National Curriculum statutory requirements[68]

Number – number and place value

- read, write, order and compare numbers up to 10,000,000 and determine the value of each digit
- round any whole number to a required degree of accuracy
- **use negative numbers in context, and calculate intervals across 0**
- solve number and practical problems that involve all of the above

Number – addition, subtraction, multiplication and division

- multiply multi-digit numbers up to 4 digits by a two-digit whole number using the formal written method of long multiplication
- **divide numbers up to 4 digits by a two-digit whole number using the formal written method of long division, and interpret remainders as whole number remainders, fractions, or by rounding, as appropriate for the context**
- divide numbers up to 4 digits by a two-digit number using the formal written method of short division where appropriate, interpreting remainders according to the context
- perform mental calculations, including with mixed operations and large numbers
- identify common factors, common multiples and prime numbers
- use their knowledge of the order of operations to carry out calculations involving the 4 operations
- solve addition and subtraction multi-step problems in contexts, deciding which operations and methods to use and why
- solve problems involving addition, subtraction, multiplication and division
- use estimation to check answers to calculations and determine, in the context of a problem, an appropriate degree of accuracy

Number – Fractions (including decimals and percentages)

- use common factors to simplify fractions; use common multiples to express fractions in the same denomination
- compare and order fractions, including fractions >1
- **add and subtract fractions with different denominators and mixed numbers, using the concept of equivalent fractions**
- **multiply simple pairs of proper fractions, writing the answer in its simplest form [for example, 1/4 × 1/2 = 1/8]**
- **divide proper fractions by whole numbers [for example, 1/3 ÷ 2 = 1/6]**
- associate a fraction with division and calculate decimal fraction equivalents [for example, 0.375] for a simple fraction [for example, 3/8]
- identify the value of each digit in numbers given to 3 decimal places and multiply and divide numbers by 10, 100 and 1,000 giving answers up to 3 decimal places
- multiply one-digit numbers with up to 2 decimal places by whole numbers
- use written division methods in cases where the answer has up to 2 decimal places
- solve problems which require answers to be rounded to specified degrees of accuracy
- recall and use equivalences between simple fractions, decimals and percentages, including in different contexts

Ratio and proportion

- solve problems involving the relative sizes of 2 quantities where missing values can be found by using integer multiplication and division facts
- solve problems involving the calculation of percentages [for example, of measures and such as 15% of 360] and the use of percentages for comparison
- solve problems involving similar shapes where the scale factor is known or can be found
- solve problems involving unequal sharing and grouping using knowledge of fractions and multiples

4.3 Increase the rigour of reasoning and problem solving

Recommendation 3	
3	**Increase the rigour of mathematical reasoning and problem solving for all students**, including specifying more clearly what, when and how students should learn.

The importance of reasoning and problem solving

Proof is the heart of maths; its purpose, not a peripheral topic[69]. The ability to engage in proof is built through practising 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[70]. The curriculum expects students to demonstrate reasoning by following a line of inquiry through conjecture, argument, justification and proof; and it expects students to solve problems by applying their knowledge with increasing sophistication to a variety of more- and less-routine problems.

Yet despite being stated aims of the curriculum, in our consultations we heard that reasoning and problem solving are inconsistently embedded in classroom practice. Fewer than half of teachers that we polled were confident that 80% of their students could "reason mathematically ... at a reasonable standard for their age"[71].

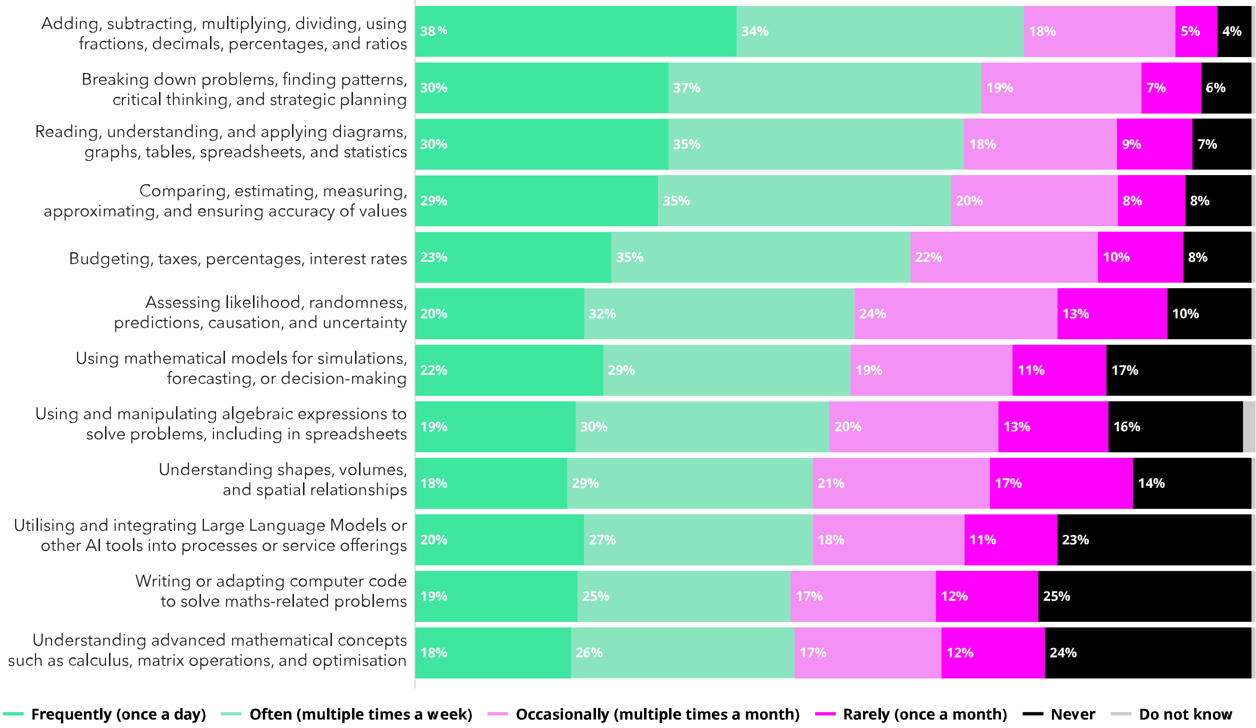
Additionally, Ofsted found that curriculum planning for problem solving is "uncommon", reporting that: "Decisions about problem solving are often left to individual class teachers. The quality of these decisions is variable. As a result, some pupils, particularly those who find learning maths more challenging and those taught by non-specialist teachers, are not effectively taught how to solve problems mathematically.[72]"

Figure 4 Problem solving

More-routine problems typically involve applying a well-rehearsed method to a familiar type of exercise, in which the main demand is accurate execution. In less-routine problems, the solution pathway is not immediately obvious, so students must explore how to approach the problem, including selecting strategies, making connections, reasoning logically and often persevering through multiple steps.

Some problems are "real-world" and embedded in an authentic situation, in which grasping the context and vocabulary is essential to modelling and employing the relevant maths. Other problems are "abstract" and intrinsically mathematical, using numbers, symbols and patterns to represent logical challenges or puzzles. Abstract problems are often presented "as if" in context (for example replacing an unknown "n" with "number of apples"), which can help to disambiguate the relationships involved, rather than confuse or distract from them. This is especially important for younger students, who may not yet be confident with the symbolic representations used in later maths learning.

As well as being central to maths education, reasoning and problem solving are highly valued by employers. In our polling, 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 these skills (44% for both of the above groups of skills)[73].



High-performing countries like Singapore and Japan provide detailed guidance on how to teach reasoning. They see problem solving as a crucial part of maths education, not an optional one, and develop reasoning through structured tasks, clear use of representations and argument patterns. Japan's curriculum standards state: "We will enrich the kind of teaching in which students are taught to think systematically, in logical steps, by reasoning; and to understand the connections among words, numbers, algebraic expressions, figures, tables, and graphs. This kind of teaching will allow students to learn appropriate usage, problem solving, how to explain one's ideas clearly, and how to express and communicate one's ideas to others."[74]

Improving reasoning and problem solving

Through our analysis, 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 countries like Singapore and Japan.

- **Value and expectations**: Reasoning is often seen as only for high-attaining students.
- **Crowded curriculum**: Teachers struggle to find time to teach reasoning well.
- **Teaching challenges**: Many teachers lack support to teach less-routine problems.
- **Assessment bias**: Tests often favour procedural fluency over reasoning.

1. Value and expectations. Reasoning and problem solving are often seen as being relevant only for higher-attaining students. This stands in contrast to subjects like English, where all students are expected to engage in creative and interpretive tasks. Although the National Curriculum refers to "solving problems," it does not specify the type, level or associated knowledge. As a result, common curriculum materials tend to focus on more routine problems that are tied to newly-taught content, rather than opportunities to apply and extend familiar content through reasoning and problem solving.

2. Crowded curriculum. As noted, there is a widespread belief that "there is too much maths to cover", and teachers therefore struggle to find time for students to practise reasoning and problem-solving activities. In our consultations, we heard that problem solving is often positioned as an "extension activity", rather than an integral part of maths, and offered only to higher-attaining students. We also heard views that reasoning and problem-solving activities tend to be put at the end of lesson plans or worksheets, making them largely inaccessible to students who are still securing their knowledge of the new content.

3. Teaching challenges. Dr Colin Foster highlights the "problem of teaching problem solving", which is this: If students are shown how to solve a type of problem and given more of the same, it is not problem solving; if they are just given lots of problems and left to struggle, it is not teaching[75]. In our consultations, we heard that some teachers, particularly those who are not specialist maths teachers, struggle to teach reasoning and problem solving effectively, and consequently prefer to "play it safe" by focusing on more-routine questions.

4. Assessment bias. National assessments such as Key Stage 2 SATs and GCSEs have a bias towards questions that require routine calculations, rather than interpretation or analysis. Assessments often ask for calculations based on small quantities of data, and reasoning and problem-solving questions are often broken down into bite-sized chunks. This discourages teachers from using classroom time to prioritise less-routine problems. While we heard appreciation for recent reforms to increase the use of larger datasets, especially at A-Level, several respondents told us that the small number of available marks means that this is being deprioritised or even ignored in some schools.

To overcome these barriers, there must be a re-conceptualisation in England of what it means to learn maths: not just mastering procedures, but developing knowledge of the definitions, representations and reasoning structures that are specific to maths. This knowledge should be verbalised, flexible and conceptually rich.

Reasoning requires explicit teaching. Students must be taught how to re-represent problems (e.g. switching a word problem into algebraic form, turning a combinatorics task into a diagram) and how to use argument patterns (e.g. contradiction, working backwards). Without being given language for these tools and taught to use them, students cannot make connections across problems, or see maths as a network of inter-related ideas. These tools must be sequenced, taught and practised.

Problem solving also requires explicit teaching. All students should be taught to recognise which information in a problem is relevant and how to adapt known processes to new situations. For example: knowing how to simplify 12/21 into 4/7 is not sufficient, students must also know that this transformation maintains the same ratio, and why. Building this kind of knowledge allows students to solve problems by selecting appropriate strategies and by transforming representations logically and deliberately.

Sequencing is crucial, too. Effective problem solving depends on having secure knowledge of the content, but curriculum designers too often pose less-routine problems in areas that students are encountering for the first time. Instead, the focus should be on familiar content, which has been introduced and practised at an earlier stage.

This is the approach taken in the "maths circles" run by Axiom Maths, in which students explore problems in integer arithmetic in Year 7, or in linear equations in Year 9[76], for example. As well as being taught explicitly, problem solving should typically be done while revisiting familiar content, which offers the ideal context for tackling less-routine problems and developing problem-solving skills.

Above all, classroom culture must change. As demonstrated in high-performing countries such as Singapore and Japan, there needs to be a shift from treating reasoning and problem solving as added extras, to making them common features of teaching practice. Students need regular exposure to less-routine problems where the method is not immediately obvious; this requires them to first make sense of the task, whether through re-representation, analogy or reasoning.

Recommendation 3	
3	**Increase the rigour of mathematical reasoning and problem solving for all students**, including specifying more clearly what, when and how students should learn.

We believe that mathematical reasoning and problem solving are not separate strands of maths that can be visited in isolation: they are part of what it means to do maths. The curriculum should reflect this at every level. Therefore, our recommendation is that the National Curriculum should affirm that all students are expected to be on the journey towards proof, and that the knowledge required for reasoning should be specified and its progression rigorously mapped.

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

- 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.

4.4 Introduce low-stakes gateway checks of fundamental knowledge

Recommendation 4	
4	**Introduce low-stakes gateway checks of fundamental knowledge**, to be administered nationally at specified points in new knowledge-progression maps.

The landscape for statutory assessments in maths up to age 16 currently includes four items: (i) A baseline assessment, taken in reception; (ii) The multiplication tables check, taken in Year 4; (iii) Key Stage 2 SATs, taken in Year 6; and (iv) GCSEs, taken in Year 11.

This is a somewhat lighter assessment schedule than in recent years. Key Stage 1 SATs (taken in Year 2) were discontinued in 2023 and replaced by the reception baseline assessment as the starting point for measuring progress at primary level. Key Stage 3 SATs (taken in Year 9) were discontinued in 2008, largely due to logistical failures and concerns about their impact on teaching and learning[77], leaving a gap in standardised national data between ages 11 to 16.

In our consultations, we heard appreciation for the way that these now discontinued national assessments – including Key Stage 1 and Key Stage 3 SATs – provided schools with external benchmarks for attainment and progress. The data was seen as especially valuable for schools that serve disadvantaged communities, or that have high student-mobility, as it helped contextualise their tracking.

Many contributors suggested that new classroom assessments could be introduced to help teachers and school leaders prioritise, by providing additional and timely data on how students compare nationally, but without the problems associated with high-stakes exams, such as Key Stage 2 SATs and GCSEs.

Gateway checks could use various methods to assess how securely students have learned concepts, methods and facts, including: one-to-one or small-group question and answer, and pen-and-paper or digital tests. Gateway checks could also fill a current gap in the data, given that Key Stage 2 SATs and GCSEs are spaced five years apart, spanning a period in which many students experience a drop-off in maths attainment and attitudes.

Gateway checks can provide information about students' learning in a way that avoids some of the negative impacts of high-stakes exams. These include the significant pressure and reputational implications for school leaders and teachers, and the fact that accountability for these exams is based on the overall mark or grade, which often incentivises "teaching to the test" to maximise overall marks.

Low-stakes gateway checks, administered nationally at critical points in the curriculum could help to address these issues[78]. Excluding the results of gateway checks from school performance tables would help to avoid the pressure that can lead to curriculum narrowing and excessive test-preparation. This environment would allow the checks to function as diagnostic tools, which would help teachers to identify specific areas in which students have insecure knowledge, and provide support as needed. The results of gateway checks would also provide schools with reliable benchmarks and a shared reference-point for student attainment.

One example of a gateway check is the multiplication tables check, which became a statutory requirement in England in 2021. The check is taken by Year 4 students (ages eight or nine). 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", which should be prioritised so that students are able to perform more complex mathematical operations; and that the checks encourage teachers to ensure that this knowledge is secure.

In our consultations, we heard some concerns about unintended consequences of the multiplication tables check[79]. While the importance of multiplication facts is generally undisputed, critics argued that the strict time pressure can disadvantage students with special educational needs, processing difficulties or anxiety, even if they have secure knowledge otherwise. Others noted that, although the test seems to be low stakes, the absence of an official "pass mark" has led to assumptions that only full marks are acceptable, particularly as the Government reports the proportion of students who achieve full marks.

On the other hand, many respondents felt that fluency in multiplication facts is highly beneficial for students, especially those who struggle in maths, as it reduces the cognitive load when completing other complex tasks. Some argued that the time limit encourages efficiency and stamina, which prepare students for later learning, and some even suggested that the time limit may be too generous, as it allows students to use inefficient strategies, such as finger-counting.

Overall, our view is that the multiplication tables check is a helpful feature of the assessment system, which incentivises schools to focus on developing secure knowledge and automatic recall, which is important for all students and especially for those who may otherwise fall behind.

We believe that it would also 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 number bonds; and in Key Stage 3 for multiplicative and proportional reasoning. These checks should be administered nationally at specified points in new knowledge-progression maps.

We also believe that the multiplication tables check should be retained as a part of a suite of gateway checks, but that research should be undertaken to re-examine whether the current setup (e.g. length of questions, gaps between questions) are optimal. In addition, it would be helpful to examine whether the Government reporting the proportion of students who achieve full marks is having a positive impact on the system.

Recommendation 4	
4	**Introduce low-stakes gateway checks of fundamental knowledge**, to be administered nationally at specified points in new knowledge-progression maps.

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.

Alongside these gateway checks, we believe that it is crucial to embed regular assessment opportunities directly in curriculum resources, in order to support day-to-day monitoring of learning and the appropriate adaptation of teaching. Curriculum designers and ed tech developers should include questions that are aligned with gateway checks in their products, and professional development for maths teachers should also encourage and support the understanding and use of these.

Examples

Gateway checks should be administered nationally at specified points in new knowledge-progression maps, from Key Stage 1 to Key Stage 3. We recommend that some or all of the following gateway checks should be introduced.

Key stage / Age	Possible content	Advantages	Disadvantages
Key Stage 1 Ages 5 to 7	Students would compose and decompose numbers, sets of objects and basic shapes, recognise simple number patterns and recall number bonds.	Introducing a check at this stage would occupy the current gap in national assessment data and raise awareness of the fundamental role that this knowledge plays in later achievement.	Critics argue that reintroducing national assessment so early could place undue pressure on young children and add to teacher workload, even if the stakes are kept low.
Lower Key Stage 2 Ages 7 to 9	The check would require students to show a secure understanding of place value within the base-10 system and to represent and manipulate larger numbers with confidence.	A focus on core number ideas at this point would complement the multiplication tables check and promote deeper knowledge of the number system.	Some stakeholders feel that the multiplication table check content might be better absorbed into the upper Key Stage 2 gateway check, rather than creating a separate assessment.
Upper Key Stage 2 Ages 9 to 11	Students would calculate with whole numbers, extending addition, subtraction, multiplication and division knowledge beyond factual recall.	Broadening the assessment beyond multiplication-fact recall would reinforce the application of those facts in real and abstract calculation contexts and reinforce the value of the multiplication tables check.	Scheduling the check close to Key Stage 2 SATs could increase workload and stress unless it was moved earlier in Year 5 or Year 6.
Key Stage 3 Ages 11 to 13 *As recommended by Mathematical Futures.*	In line with the Mathematical Futures recommendation, the assessment would test multiplicative and proportional reasoning, including scaling quantities, interpreting graphs and solving ratio-based problems.	Establishing a clear yet low-stakes milestone in a frequently overlooked key stage would improve progression clarity and provide robust national data on early-secondary attainment.	If schools use the results as a primary determinant of GCSE tier entry, the check risks becoming high-stakes and creating additional pressure for students.

Our favoured option is to introduce gateway checks at all the above key stages. At a minimum, we recommend the implementation of the Key Stage 3 check.

4.5 Reform the Key Stage 2 SAT exams

Recommendation 5	
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.

SATs were introduced in the 1990s to provide a national benchmark for attainment and progress, and as a means for holding schools accountable. Today, the Key Stage 2 Maths SAT is taken by all Year 6 students (age 10 or 11). The exams consist of three written papers: one 30-minute arithmetic paper and two 40-minute reasoning papers, the latter of which involve applying maths knowledge to solve contextualised problems.

In 1995, only 45% of students achieved at least Level 4 in the Key Stage 2 Maths SAT[80] (a grade deemed to show readiness for secondary maths). This rose to around 80% of students by 2015[81], after which the grading system was changed to include an "expected standard", based on scaled scores. This new expected standard is achieved by around 75% of students today, but the threshold for achieving it 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[82].

For two decades, the assessment model was that Year 6 students took two written papers, along with an audio mental maths exam. 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 get less recognition for demonstrating agility in areas such as part–whole relationships, equivalence and comparison of fractions and decimals, and order of magnitude estimation.

In our consultations, we heard many respondents say that the fastest route to achieving expected standards in the Key Stage 2 Maths SAT 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 mechanical exercises, with "drilling" beginning as early as the January before the summer exams. This results in a consequent weakening of number knowledge and strategic thinking.

While SATs offer reliable, large-scale data, there is little evidence that their current design helps students to develop the fundamental knowledge needed for secondary maths. While many high-performing countries use national assessments at the end of primary school, they pay careful attention to the impact on classroom practice. The Singapore Primary School Leavers Examination for maths focuses on fundamental knowledge, logical reasoning and problem solving[83]. The guidance explicitly signals to teachers that the priority is deep, coherent learning. This is reinforced by the inclusion of less-routine problems, which test students' ability to apply their knowledge[84]. These exams serve not only as a summative assessment, but also as a guide for pedagogical priorities in primary schools[85].

We believe that the Key Stage 2 SAT exams in maths should be redesigned, keeping four principles in mind:

1. Application. An important purpose of any national assessment at the end of primary school should be to confirm that students can apply their number knowledge, not just use a rehearsed catalogue of procedures. In our consultations, we heard that many students who meet the expected standard in Key Stage 2 SATs can execute long multiplication, yet falter when asked whether "3,120,000" is a plausible answer to the question "What is 24 × 1,300?" In short, students lack the habits of approximation, proportional reasoning and unit awareness, which underpin algebra and data knowledge at Key Stage 3.

2. Reasonableness. The assessment should call on students to justify the reasonableness of their answers. Prompts like: "How do you know that your answer is sensible?" or "Explain why this person's estimate must be too high" can help to nurture students' meta-cognition (i.e. thinking about one's own thinking) and expose misconceptions that may remain hidden. The assessment should include more questions that allow multiple solution paths, which would reward efficient reasoning but not penalise slower, methodical work.

3. Agility. The assessment should elevate mental agility and the use of informal approaches by allocating a proportion of the marks to estimation, rounding, decomposition and the use of derived facts. For example, this could be done by amending Paper 1 to focus more on mental methods, or through restoring a short, verbal mental maths paper. Either way, questions such as "One sixth is 8 cm. How long is the whole ribbon?" are quick to mark, yet provide a sharp distinction between students who are less- and more-secure in their knowledge of multiplicative structures.

4. Expected standard. The threshold for the expected standard must be high enough to demonstrate that students have achieved comprehensive fundamental knowledge. The current threshold is around half marks. We believe that the threshold should be increased to around 75% and that this should be phased in over a reasonable time period (e.g. three years).

Recommendation 5	
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.

By raising the expected standard, and by embedding application, reasonableness and agility, reformed Key Stage 2 SAT exams can promote richer classroom maths and provide a reliable indicator that students are ready for the algebraic, geometric, proportional and statistical thinking in the secondary curriculum.

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 around 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 undervalued relative to written arithmetic.

We recommend that any solution in this space should satisfy the following criteria:

- Cover the full primary national curriculum in maths.
- Incentivise the teaching of fundamental knowledge, including calculations with known methods and mental maths.
- Incentivise the teaching of problem solving, including less-routine and multi-step problems.
- The expected standard should demonstrate comprehensive fundamental knowledge.
- Feasible to implement within the current system, including constraints in school resources (e.g. staffing, digital infrastructure) and school accountability measures.

Options to reform the Key Stage 2 SAT exams

The following table sets out our analysis of potential components of reform of Key Stage 2 exams. We recommend all but the last component in the table.

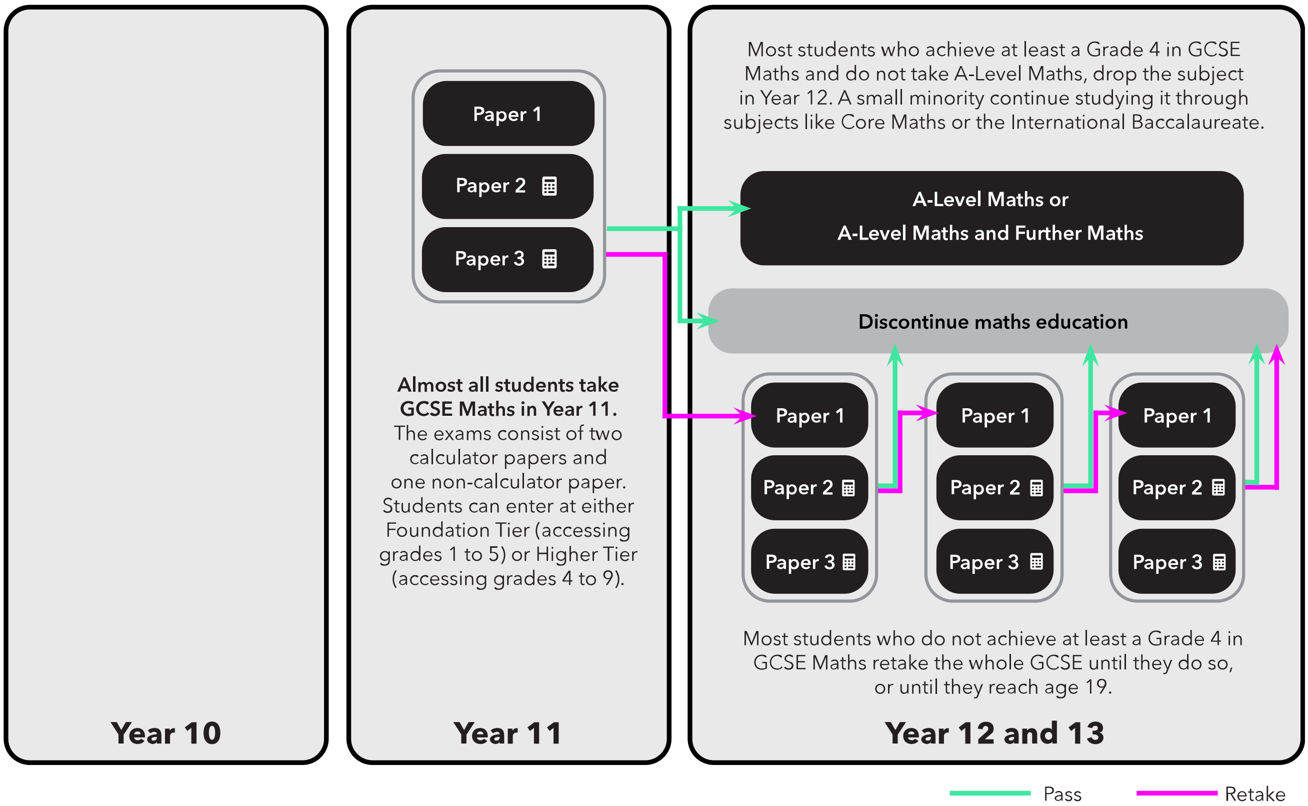
Components	1: Curriculum coverage	2: Knowledge	3: Problem solving	4: Expected standard	5: Feasibility	Comments
Increase the focus on mental maths (either through design of questions or reintroducing an audio playback of questions).	-	✔	-	✔	✔	It is possible to design questions that are quick to mentally calculate and laborious using manual methods; these could improve assessment of mental maths. Reintroduction of the audio recording should be possible as it was commonplace previously, although audio quality and system reliability is key.
Reduce the number of marks available for procedural maths and increase the marks available for other content: less incentive to focus most teaching time on drilling procedural questions.	✔	X	✔	?	✔	By reducing marks in this way, it may even out the excess focus on the more procedural maths in Paper 1, although the reformed version can still be "gameable" in other ways.
Increase the proportion of assessed content that is fundamental knowledge, in particular number and calculation.	✔	✔	-	✔	✔	By shifting to greater focus on the security of the fundamentals, all stakeholders can be more confident that there has been mastery of the maths that is most key to progressing onward.
Increase the emphasis on reasoning and problem solving.	✔	X	✔	X	✔	By increasing the emphasis on problem solving, there is greater incentive to make this type of question central to teaching during the primary phase.
Increase the 'grade boundary' for attaining national expectations to around 75%.	✔	✔	✔	✔	?	A grade boundary change could ensure secure learning across a broader range of the curriculum although there could be issues about making it comparable to previous years in data series.
Change SATs so that they are no longer marked with a score but pass/fail only.	X	X	X	X	X	While some in our consultation argued that this would be less distorting, this would require an overhaul of the accountability system (which is beyond the scope of our report). In addition, it is not clear if this change would have significant impact on classroom practice or student attitudes.

4.6 Reform the GCSE exams

Recommendation 6	
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.

GCSE Maths holds a powerful position in England's education system, including as a springboard to further study and work. In 1995, 53% of students had achieved what was then called a "good GCSE pass" (Grade C) by the age of 19[86]. Today, GCSE Maths is taken by almost all students at 16, and around 80% of students achieve the equivalent standard of a good GCSE pass, now called a "standard pass" (Grade 4), by age 19[87].

The exams consist of one non-calculator paper and two calculator papers. Students can enter at either Foundation Tier (accessing grades 1 to 5) or Higher Tier (accessing grades 4 to 9). Most students who do not achieve a Grade 4 in GCSE Maths will continue to retake the whole GCSE until they do so, or until they reach age 19. These students can retake all three papers each autumn and again each summer.



The design of GCSE Maths 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. In our consultations, we heard various concerns that GCSE Maths is not meeting the needs of students:

1. High stakes. We heard worries that GCSE Maths is a high-stakes exam that can create anxiety for students and teachers, and that this can lead to sub-optimal teaching strategies, such as revision-cramming and "teaching for the test". However, other high-performing countries arguably have higher-pressure exams. For example, Shanghai's Zhongkao exam, taken around age 15, is a critical gateway that determines admission into tiered schools and significantly impacts life chances[88]. Similarly, Japan uses high-stakes entrance exams around age 15 for selective admission into upper-secondary schools[89] and Singapore's GCE O-Levels are also crucial for progression to further study and work and hold considerable national currency and esteem[90].

2. Standard pass. The current grading system may not signal maths 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[91]. This means it is possible to achieve a Grade 4 on either tier without having demonstrated a broad grasp of many important concepts, facts and methods.

3. Retakes. Despite retakes being compulsory for students who do not achieve a standard pass in GCSE Maths at age 16, around 20% of all students still do not achieve one by age 19. For many, this is after 15 years of study and an estimated 1,600 hours of maths lessons. We believe that these students are owed a better experience of the retake system and that, with the right support, they can succeed in far greater numbers.

In our consultations, we heard that a number of students are entered for their first retake in November, having had barely any additional maths lessons since the summer, and little opportunity to secure the knowledge needed. Some students continue to retake at every opportunity, with research from Impetus suggesting that some students are entered for retakes up to nine times[92]. Research from Cambridge Assessment suggests that each successive retake session sees a lower proportion of students achieving a standard pass[93].

4. Lack of challenge and stretch. The experience of higher-attaining students is also sub-optimal. While there is extensive coverage of factual content and methods, there is limited focus on mathematical reasoning and problem solving. A growing number of schools are responding to this problem by offering a Level 2 Further Maths qualification, which is intended to provide additional stretch. However, many teachers and students told us that this simply offers more of the same: extra content, but little in the way of inspiration or intellectual challenge.

5. Assessment choices. The design of assessments can create tensions for classroom priorities and teaching approaches[94]. For example, calculator papers open up a range of analytical and problem-solving questions, but the use of calculators can reduce the emphasis on mental maths in the classroom. Likewise, paper-based exams are highly valued for their practicality and accessibility, but they may reduce the time spent on important digital competencies in classrooms.

Multi-stage questions can help avoid the situation where students trip at the first hurdle and forego all the available marks on a question but these questions can also reduce incentives to teach extended reasoning. Coursework could be used as a way of assessing extended reasoning, as well as statistical inquiry and the use of technology. However, we heard several concerns about implementing coursework, including the ability to ensure authenticity when students have access to AI, and the impact on timetables and workload, which tend to favour well-resourced schools.

In our consultations, we heard many suggestions on 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[136]. In Wales, a 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 that is worth two GCSEs[137].

The content of the GCSE is determined both by the programme of study for Key Stage 4 and the government specification for the maths GCSE. In our consultation, we heard calls for reducing the content of the GCSE Foundation Tier and a range of options for content at the Higher Tier. Maths Horizons' mapping of curriculum content found that the current pitch of both tiers is broadly in line with leading international jurisdictions at both Foundation and Higher tier and is generally suitable. We heard proposals for several suggested tweaks but most of these would make little difference to the volume of content that needs to be covered.

Based on our evidence and analysis, we believe that the right approach is to maintain a single GCSE in maths. The current 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 very likely widen socio-economic gaps and face the same fate as the failed pilot in England and the abandoned policy in Wales.

Recommendation 6	
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.

In our recommendation to reform the GCSE Maths exams:

- We recommend the introduction of a gateway paper for all students that focuses on the most fundamental maths knowledge. Access to GCSE grades 4 or above would only be possible if students attain a high threshold mark on this paper.
- We recommend increasing the proportion of marks allocated to reasoning and problem solving, which are currently undervalued relative to recall of facts and routine applications.
- We recommend that, if students do not achieve a standard pass in GCSE Maths, they should first retake the gateway paper and then retake the other papers. To reduce the volume of retakes, a standard pass on the gateway paper should be portable across retake sessions, so students avoid having to redo it.

We recommend that any solution in this space should satisfy the following criteria:

- The credibility of the GCSE is maintained and is accessible to all students: there should not be a lower-status pathway for some students, and standards should not be lowered to engineer higher pass rates.
- A standard pass should demonstrate comprehensive fundamental knowledge: it should not be possible to achieve a standard pass while having limited or insecure knowledge.
- Students who are retaking GCSE Maths should have a more positive experience: there should be better support to acquire the fundamental knowledge needed and a lower burden of exams.
- The type and range of questions chosen for GCSE Maths papers should have a positive influence on the teaching of maths in key stages 3 and 4, including a greater focus on mathematical reasoning and problem solving.

Options to reform the GCSE exams

The following table sets out our analysis of leading proposals for GCSE reform. Our preferred approach is the last one: the introduction of a gateway paper.

Option	1: Pathway	2: Standard pass	3: Retakes	4: Teaching	Comments
Retain the existing model of GCSE Maths, with no major structural changes. Continue to assess all content at the end of Year 11 through terminal examinations, as per the currently approach.	✓	X	X	X	Retaining today's structure would spare teachers, exam boards and curriculum publishers a disruptive overhaul, and it would preserve a qualification that is familiar to students, parents and employers. However, Grade 4 can still be reached with worryingly low raw marks, so the signal of broad competence remains weak. The compulsory resit regime would stay high-stakes and demotivating, and the format would continue to steer teaching towards exam-tip rehearsal rather than deeper reasoning and problem-solving.
Replace the GCSE with a system of competency badges or "micro credentials". Students would be assessed on discrete mathematical topics such as ratio, data, or algebra through short assessments taken when they are ready.	?	X	X	X	Assessing small clusters of content when students are ready could let learners build a record of success over time, potentially improving motivation for current resitters. Yet the absence of a single, synoptic certificate risks creating a fragmented, lower-status pathway whose currency with employers and admissions tutors is doubtful. Because each badge would be tested in isolation, there is a danger that teaching would narrow to checklist coverage, sacrificing coherence and conceptual depth.
Introduce a half-GCSE in maths, to be taken by all pupils at the end of Year 10. It would be certificated as a standalone qualification, recognised by further education providers and employers, and would count as the first half of a full GCSE for those continuing to Year 11.	X	✓	?	✓	A mid-course certificate offers students an early milestone and might boost confidence, but it adds another set of examinations and may pull classroom attention towards test-readiness too soon. Schools could be tempted to treat the short course as an end-point for lower attainers, hard-wiring ceilings into pathways. Employers and universities may be uncertain how much weight to attach to the half-GCSE, and students who still need Grade 4 will have to sit the remaining papers anyway.

Option	1: Pathway	2: Standard pass	3: Retakes	4: Teaching	Comments
Retain the current GCSE but introduce a new, one-year "GCSE Step" qualification only at resit stage for students who achieved a Grade 2 or below. GCSE Step would cover approximately half of the current Foundation tier curriculum and be taken in Year 12, with the current, full GCSE then attempted in Year 13 if passed. It would be assessed in a single summer exam series and recognised in accountability and funding systems.	✓	✓	✓	X	By covering roughly half of the Foundation-tier content, GCSE Step would give students who scored Grade 2 or below a fresh start post-16 and an achievable stepping-stone towards the full GCSE. Lower content load and a clear recognition point could lift confidence and motivation, while an explicit focus on fundamentals supports secure knowledge in the post-16 phase. The downside is that no change to the Year 11 paper means no additional incentive to focus on fundamentals in Key Stage 3 and 4.
Retain the current GCSE but replace the current resit model with a redesigned post-16 GCSE, covering content that is halfway between the current GCSE and a Functional Skills qualification. It would have higher grade boundaries for broader competency, and would also have a 'stepping stone' qualification that can be optionally used to test more basic skills.	?	✓	✓	X	A distinct post-16 paper, pitched midway between GCSE and Functional Skills, could offer a different assessment experience with higher boundaries that underline the need for broader competence. The trade-off is the risk of lower currency: employers and universities might not treat the new post-16 GCSE–or its optional stepping-stone–on a par with the mainstream Year 11 version because of divergent content and perceived proximity to the less-trusted Functional Skills route.
Retain a single GCSE qualification with two tiers and introduce a mandatory, non-calculator "Gateway" paper. A pass on the Gateway paper (focused on fundamental maths knowledge) would be required to achieve Grade 4 or above. Students then take slimmed down GCSE papers on the rest of the GCSE content. The Gateway paper would be portable across sittings (i.e. once passed, it wouldn't need re-taking in future resits). This model supports a more streamlined 16–19 resit pathway and emphasises foundational numeracy as a prerequisite for higher grades. A variant is to allow students to take the Gateway paper early, in Year 10.	✓	✓	?	✓	All students would sit the Gateway paper, which concentrates on fundamental knowledge and would be a prerequisite for achieving Grade 4 or above. This protects the single-pathway model and strengthens the link between a pass and secure fundamentals. It should encourage more classroom time during Key Stages 3 and 4 on fundamental maths and non-calculator reasoning, although the mixed cohorts during transition to sixth form or further education (some with a Gateway pass and some without) and the limited external value of a Gateway-only pass introduce complexity, and students still face re-examination albeit with fewer papers. The optional additional component of allowing an early attempt (e.g. in Year 10) gives clear structure and can make subsequent resits less burdensome because the Gateway mark would be portable between sittings, although there remains a risk of over-focus on test preparation in Year 10.

4.7 Explore a maths entitlement for 16- to 19-year-olds

Recommendation 7	
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.

There has been impressive growth in the take-up of A-Level Maths, which is now the most chosen A-Level course. A new record was set in 2024, with over 100,000 A-Level Maths entries in England, representing over half of all students that took A-Levels[95]. Another record was also set in 2024 for A-Level Further Maths entries, with over 18,000 students in England taking the course[96].

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%) or the International Baccalaureate 16-19 maths components (0.3%)[97]. While this is a good start, our vision is for a third of students to gain at least a Grade 7 and to progress to A-Level Maths or another form of advanced mathematical study.

Many advanced economies, including Canada, France and Germany, and Shanghai in China, require students to continue with maths until age 19[98]. Unlike in many peer countries, in England it is not mandatory to study maths beyond age 16 and so, for most students, 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 "maths to 18" being compulsory[99].

The 2017 Smith Review recommended that England should make it compulsory for all students to continue studying maths to age 18, although it noted that the Government must first address the availability of Core Maths and increase the supply of maths teachers. In 2023, the then Government set up a working group to create a blueprint for an "Advanced British Standard", which would include compulsory maths to age 18[100]. Although the current Government has not continued the Advanced British Standard initiative, it has launched a Curriculum and Assessment Review, which will provide another opportunity to re-assess these questions.

Pathways for advanced mathematical study

Maths Horizons' vision is for almost all students to achieve a standard pass in GCSE Maths, and for a third of students to progress to advanced mathematical study. This would involve a large increase in the number of students taking A-Level Maths, and other post-16 courses such as Core Maths. We are optimistic that this will be possible. For example: if girls could be supported to take A-Level Maths at the same rate as boys, this would result in around 28,000 more students each year[101] and if girls could be supported to take A-Level Further Maths at the same rate as boys, would result in around 7,000 more students each year [102].

1. Core Maths. 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 maths study, this means that around 54% of students are dropping maths at age 16[103]. 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, and the course 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.

2. A-Level Maths. In our consultations, we heard varied opinions about the content of A-Level Maths, with some respondents questioning how effectively the 2017 curriculum reforms are working.

Some respondents suggested that A-level Maths is too focused on "manual calculations" and does not have enough focus on problem solving or proofs. For example, one person noted that "*[it] would be much more beneficial for students to have more time to make connections and engage in problem solving. These are both essential in everyday life and at A Level Maths*." Others reflected their frustration that too many students emerge from school with an expectation that maths is all about "turning the handle and producing an approved answer".

Other respondents suggested that England should reconsider its unusual approach of including mechanics as part of maths (with other countries placing it only within the physics curriculum), and look at incorporating other content in its place. For example, one respondent noted that: "The heavy emphasis on mechanics and physics feels very old-fashioned and many of the things that could link maths to more modern endeavours (such as graph theory, algorithms, logic etc) are missing".

These consultation responses are backed up by research. For example, one analysis showed that 90% of the A-Level Maths Core 1 paper was "factual recall and routine procedures" compared to around 5% "application of conceptual knowledge to construct mathematical arguments"[104]. Another analysis noted that the "UK is unique amongst the jurisdictions investigated for incorporating its mechanics content into mathematics courses, rather than physics"[105].

More generally, respondents noted that several important topics have insufficient marks allocated in exams, and that the questions on these topics 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."

We recommend the launch of a separate review of A-level maths and further maths content that should explore how effectively the 2017 curriculum reforms are working, including the exam marks allocated to data handling, problem solving and proof. It should also recommend whether to substitute some newer topics and maths domains for some of the more traditional ones currently specified.

3. A-Level Further Maths. Currently, A-Level Further Maths is structured as an additional qualification that is taken alongside A-Level Maths. In our consultations, many teachers expressed concern 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[106], there is still more work to do.

A more-flexible structure for A-Level Further Maths could help to expand the pool of students who take the course and who prepare for maths and other quantitative degrees. One option could be 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 begin with the A-Level Maths content, but students would move through the material. One option could include requiring more study-hours for this than the current A-Level Maths course, although the feasibility of this needs to be tested.

A maths entitlement for 16- to 19-year-olds

We believe that there is a strong case for extending maths learning to the end of compulsory schooling, by age 19. As Green and Kaye note in a recent research report: "There is substantial research evidence to suggest that compulsory maths [to age 19] not only correlates with higher numeracy levels amongst young adults across countries, but also contributes to mitigating skills inequalities inherited from lower secondary education. Our recent research […] shows that, during the upper secondary stage, there is a significant improvement in numeracy skills, as well as reductions in numeracy and literacy skills inequality associated with systems where maths (and national language) are compulsory for students up to the end of upper secondary education (e.g. South Korea, the Czech Republic and Slovenia)"[107]. In the UK, poor numeracy is estimated to cost the economy up to £25bn a year due to lost productivity and lower wages[108], so the potential benefit of extending maths learning to age 19 is high.

As noted in the 2017 Smith Review, a key implementation challenge in introducing a maths entitlement for 16- to 19-year-olds is deciding how to staff this additional teaching time, and how this additional teaching time might fit within the wider timetable. While this is undoubtedly a challenge, international evidence suggests that students in England average 1,280 hours of teaching in Key Stage 5, compared to 1,700 hours in Italy and Canada, and over 2,000 hours in France and many US states[109].

Recommendation 7

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.

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, and whether to substitute some newer topics and maths domains for some traditional ones.
- To pilot a standalone A-Level Further Maths course, which it should be possible to deliver within a single, augmented A-Level slot.

5. Conclusion

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 16 for advanced maths 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 will continue with engagement across education, academia and industry. 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 additional workstreams, which touch on wider issues in the education system and which we will begin in the months ahead. These workstreams are summarised in the bullet points below and expanded upon in the next section.

- 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.

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 EdTech. We look forward to developing a shared vision for England to be one of the top-performing countries in the world for maths.

Maths Horizons additional workstreams

Looking ahead: Exemplifying connections across the curriculum

To achieve mastery, students need to understand how different topics within maths connect and they need to be able to interpret and use mathematical language (like "mean", "difference" or "product") accurately, even when they are applying their maths knowledge in other subjects. Although these aims are explicitly stated in the National Curriculum[110], evidence from Ofsted[111] and NCETM[112] shows that building understanding of cross-curricular connections and mathematical language is often a challenge. Research also highlights how unfamiliarity with mathematical language can hold students back, with students from disadvantaged backgrounds or with English as an additional language (EAL) being disproportionately impacted[113].

High-performing maths education systems make connections and language explicit within their curricula, and in teaching materials. Singapore's syllabus directs teachers to "teach towards big ideas [...] so that students see and make connections among mathematical ideas within a topic, or between topics." It lists the ability to "reason, communicate, and make meaningful connections and integrate ideas across topics" as an assessment objective[114], and specifies how communication and connections should be systematically rehearsed from early primary through post-16 study.

In the coming months, Maths Horizons will explore how non-statutory guidance in the National Curriculum could be developed to include short examples of how topics link together, both within maths and to other subjects, and to list essential terms with oracy prompts.

Looking ahead: Specifying the digital tools that students should encounter

Digital tools are already transforming the use of maths in the workplace, enabling people to do more complex tasks more quickly. They present huge opportunities for education too, but we know from past research on calculator use in schools, that digital tools only aid learning when they are introduced in the right way and at the right time[115]. Computing answers mentally is important when students are securing maths knowledge[116] but introducing calculators alongside topics that students have already mastered can improve problem-solving skills and even help to build more positive attitudes towards maths[117].

As things stand, the National Curriculum is unhelpfully vague about how and when digital tools should be introduced. It cautions against using calculators "as a substitute for good written and mental arithmetic" and it makes no specific references to other digital technologies[118]. By contrast, Singapore encourages the introduction of calculators in upper primary[119], and explicitly states, for each year of study, which knowledge should be introduced with and without calculators. At secondary level, the curriculum describes the ideal use of tools, including digital manipulatives, dynamic geometry tools, graphing tools and spreadsheets.

In the coming months, Maths Horizons will explore how the National Curriculum could specify what digital tools should be encountered at each key stage. Our initial view is that, in order to build confidence in using AI and computational tools, students need a carefully-sequenced progression, starting with deterministic technologies in key stages 1 and 2, before advancing to AI-assisted tools from Key Stage 3 onwards. The aim should be for students be able to interrogate, interpret and validate digital outputs, rather than just accepting them at face-value.

Looking ahead: Exemplifying links between maths and work

In our consultation, we heard many calls to make maths relevant to students' aspirations and future lives. As one respondent put it: "Too often learners face questions that no one would ever need to answer in real life; the lack of real and relevant data is the most glaring example." We also heard concerns that attempts to incorporate real-world examples (such as payslips and household budgets) can feel superficial or have the counter-productive effect of overloading students' working memories with extraneous details.

However, we believe that exposing students to less-routine problems, rooted in real-world contexts, is a powerful way to broaden understanding of what maths is for. For example, when teaching conditional probability and statistical inference, teachers can draw explicit links to Bayes' theorem, and to the way LLMs generate text by continuously updating probability distributions, thus helping students connect classroom ideas to the AI tools they already encounter in everyday life and work.

The highest-performing education systems show how this can be embedded. In Shanghai, the curriculum requires students to "express the real world with mathematical language" and to "explore connections within mathematics, between mathematics and life". Analysis of lessons delivered by teachers in Shanghai shows how they design sequences using variation theory and insist on precise and elegant mathematical language while posing daily life and cross-subject problems[120].

In the coming months, Maths Horizons will explore how the National Curriculum could be strengthened to embed examples of how maths links to life and work. In our consultation, representatives from industry also expressed enthusiasm for helping to exemplify these links.

Looking ahead: Reforming how exams are regulated and delivered

England's maths exams deliver high statistical reliability[121], which is important for both fairness and public confidence. However, our consultation revealed that exam question design tends to reward candidates more for applying routine methods to solve highly-structured problems than for tackling open-ended problems or demonstrating conceptual and analytical skills. Independent comparisons confirm that England's exams are more scaffolded than the problem solving papers used in top performing systems such as Singapore, where exams routinely require students to devise a strategy with minimal prompts[122]. Moreover, some maths skills are inherently difficult to assess in a paper-based exam, such as creating, using and analysing models and the analysis of larger quantities of data.

Teachers told us that the design of exams leads them to focus lesson time on rehearsing familiar algorithms, squeezing out time for open-ended reasoning. Our consultation also suggested that competition between exam boards creates a perverse incentive for boards to converge on 'safe' question types rather than richer tasks, which schools are likely to perceive as riskier and 'less gameable'. Unlike in other OECD jurisdictions, where examinations and curricula are typically overseen by the same agencies, England's exam regulator Ofqual has no formal remit to consider the impact of exam design on classroom practice[123].

In the coming months Maths Horizons will explore ways in which the design and regulation of exams could be improved so that more weight is given to assessing students' mathematical reasoning. This could involve changing the remit of Ofqual to consider the impact of exams on classroom practice or moving to a single exam board per subject. It could also involve piloting screen-based exams, which allow new types of question to be assessed, drawing on the example of adaptive numeracy tests in Wales[124] and new adaptive digital platform for 'the SAT' in the United States[125].

6. 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
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Recommendations 1 to 3 in practice

In our consultations, we heard that the requirements for both shape and space, and data and uncertainty, needed attention. The challenge for both of these sub-domains is not the amount of time available, but the clarity of purpose. In recent years, progress has been made in specifying what knowledge must be taught, but insufficient thought has been given to progression and connections within and between sub-domains. The good news is that we do not need to choose between content knowledge and reasoning knowledge. Both are valuable, the goal now must be to bring them into better balance.

Summary: Shape and space

The topic of shape and space goes far beyond the boundaries of traditional geometry. It encompasses how we understand position, direction, structure, representations, and perspective, all of which are central to spatial reasoning. As the Royal Society notes, spatial reasoning is a powerful but under-utilised foundation for mathematical learning with broad benefits for maths, including geometry, measures, number, algebra and statistics[126]. Spatial reasoning connects our physical and imagined sense of attributes like length, size, and distance to their numerical and algebraic representations and enables flexible movement between them. Visualising – manipulating mental images – has been recognised as an important cognitive ability. A growing body of evidence demonstrates that spatial reasoning is a strong predictor of maths performance across all ages. Crucially, teaching students to think and work spatially not only improves maths attainment in the short term but also confers long-lasting educational benefits[127].

Moreover, spatial reasoning is a significant predictor of later engagement in STEM careers. Longitudinal research shows that secondary school students with the highest spatial reasoning scores are the most likely to pursue careers in STEM[128]. Despite this, international assessments suggest that spatial thinking is a relative weakness among English students[129]. PISA data show that spatial tasks are the lowest-performing area for 15-year-olds in England. In the 2023 Trends in International Mathematics and Science Study (TIMSS), English students in both Year 5 and Year 9 performed relatively poorly in geometry.

A case in point is the current Year 2 National Curriculum where students are expected to name and describe shapes, but the curriculum lacks guidance on how this supports wider reasoning. In the most effective classrooms, children go further – visualising, composing, and decomposing shapes to build spatial thinking. This is not a matter of choosing between specifying content knowledge and promoting thinking. Both are essential. The curriculum should continue to set out clear, progressive expectations for what children should know, while also supporting the development of spatial reasoning as a cognitive process. Shape and space should be both a distinct strand and a tool used across maths to support understanding through visual representations such as diagrams, number lines and area models.

High-performing jurisdictions in PISA and TIMSS sequence geometry teaching to build spatial reasoning systematically. In Singapore, early years geometry focuses on visualisation and real-world application, gradually moving towards formal deductive reasoning in secondary education[130]. In Japan, early experiences emphasise physical manipulation and experimentation with shapes[131]. Common to these systems is a shared view of geometry not as isolated content but as a rich opportunity to develop cognitive tools such as pattern recognition, logical deduction, and strategic problem solving – all grounded in spatial reasoning.

In practice: Shape and space

Recommendation 1: Design a curriculum for mastery

To develop spatial reasoning systematically, the shape and space strand must evolve beyond naming shapes or recalling isolated facts. A mastery approach should explicitly build the ability to compose and decompose shapes, reason about transformations, mentally visualise and manipulate structures, and understand the relationships between spatial elements. Adults can support using spatial language and gesture, encouraging spatial strategies and prompting children to sketch their predictions.

What this progression might look like:

Phase	Conceptual focus	Mastery indicators	Example activities
KS1 (Y1 to Y2)	Properties of shapes; composing and decomposing; directional language.	Describe and compare 2D and 3D shapes; construct new shapes from parts; follow/give directions.	Use tangrams and pattern blocks to compose figures, moving from a trial and improvement strategy to a visualisation strategy.
Lower KS2 (Y3 to Y4)	Symmetry; angles; turns.	Visualise, predict and sketch changes under rotation or reflection; identify lines of symmetry.	Use mirrors, paper folding and sketching to explore bilateral symmetry.
Upper KS2 (Y5 to Y6)	Transformations; nets; perspective; developing reasoning.	Justify classifications; visualise and manipulate 3D structures from 2D views.	Investigate cube nets and determine which nets form solids.
KS3 (Y7 to Y9)	Formal geometry; logical deduction; coordinate geometry.	Construct geometric arguments; describe composite transformations using coordinates.	Predict and sketch the outline of the cross section of a given 3D shape cut at different angles.
KS4 (Y10 to Y11)	Deductive reasoning; geometric proof; loci and constructions.	Construct and justify formal proofs; solve contextualised spatial problems.	Design and justify geometric models (e.g. sports court or garden) using loci and constructions.

Recommendation 2: Rebalance content from upper primary to lower secondary

To build deep and transferable understanding of geometry, foundational spatial reasoning skills must be introduced earlier and developed over time. The current compression of key spatial concepts into later primary or early secondary years undermines the opportunity to nurture visualisation, structural reasoning, and abstraction from a young age.

Examples of rebalancing:

- Introduce spatial strategies (e.g. visualisation, mental rotation, mental transformation, decomposition) in Key Stage 1 and support with spatial language and gesture. Young children can reason with parts and wholes, solve geometric puzzles and build composite structures long before they can name all the shapes involved.
- Begin transformational reasoning (e.g. translation, reflection, rotation) in years 3 and 4, using concrete resources and grid-based drawing, so that abstract reasoning builds on a strong spatial foundation.

- Incorporate 3D modelling and digital tools from Year 5, using isometric drawing, modelling software, sketching and physical construction to bridge 2D–3D spatial understanding.

- Develop structured spatial argumentation by Year 6, for example using 'Visualise, Think, Check' to encourage students to mentally picture and predict the outcome of actions on shapes before testing their ideas physically. Encourage students to justify claims using shape properties, congruence, or counterexamples. This prepares the ground for later deductive geometry and proof.

This rebalancing is not about pushing harder content earlier but about giving children richer opportunities to develop flexible and robust spatial thinking. Geometry should unfold over time as a connected and meaningful domain – not a series of disconnected facts or procedures.

Recommendation 3: Increase the rigour of reasoning and problem solving
Spatial and geometric reasoning should not be taught as lists of facts or isolated exercises. The most powerful learning comes through rich tasks that require explanation, visualisation, prediction, and logical deduction. Embedding these opportunities across key stages fosters deep understanding and maths resilience.

a. Composing, decomposing, and visualising
Example (KS1): "Here's a square and a triangle. Can you use them to make a house shape? What other shapes can you make? Can you describe how you made them?"
This task supports reasoning about part–whole relationships, spatial structure, and multiple solution paths – all core components of early spatial cognition.

b. Transformation reasoning and justification
Example (KS2): "How many different nets could make a cube?" Students can draw using squared paper, then check by cutting and folding. "Which of these fold up to make a square-based pyramid. Why/not?" Students predict the result of transformations, e.g. how more complex shapes (2D and 3D) will appear when rotated, the result of cutting and folding. Here, students reason about invariance and change and develop internal visualisation strategies that strengthen spatial memory and mental transformation.

c. Logical deduction and proof structures
Example (KS3): "All squares are rectangles. Are all rectangles squares? Use reasoning to justify your answer. Can you find or draw a counterexample?"
This task builds the foundation for deductive logic by encouraging the use of properties, set inclusion, and counterexamples – all of which are central to higher-level geometry and mathematical proof.

d. Real-world and cross-curricular applications
Example (KS4): "Design a park using scale drawing and geometric reasoning. Include pathways at right angles, circular features, and reflective symmetry. Draw one of the structures from different perspectives. Justify your design choices."
These kinds of tasks support authentic maths modelling, link to design and engineering principles, and highlight the practical value of geometric thinking across disciplines.

Summary: Data and uncertainty

Teaching data and uncertainty comes across as a strength for the English education system – 'uncertainty and data' was England's strongest component in 2022 PISA[132], beaten only by six East Asian countries, and 'data and probability' was England's strongest domain in the 2023 TIMSS[133]. Despite this, we heard in our consultations and roundtables that there is a skew in the types of topics specified in the curriculum and tested in exams. At KS2 there is particular emphasis on reading values from and constructing graphs, and on calculating totals, mean values and differences. At GCSE the focus is on: reading information from and constructing standard statistical diagrams; calculating measures (mean, median, mode, ranges) from listed data and frequency tables; comparing distributions by comparing summary statistics; interpreting scatter graphs to determine correlation and line of best fit; basic probability from data and critiquing a simple interpretation of data or a representation.

Several respondents noted that this is a very narrow sample of the topic and that there is a particular underrepresentation of:

- Planning, describing and justifying data collection and analysis methods (the data problem-solving cycle), with opportunities to construct or critique plans;
- Concepts around data bias, selective data versus representative, data 'messiness' and cleaning;
- Any depth of discussions of correlation versus causation – this is mentioned in the GCSE specification but questions tend to focus on identifying correlations in graphs, rather than, for example, critiquing and deconstructing public or media statements that confuse the two;
- Working with larger data sets using technology for analysis and visualisation (this is present in A-level maths but tends not to be prioritised by teachers).

The consequence is a shallow experience for many students, with insufficient exposure to key concepts such as sampling, variability, correlation, uncertainty and graphical representation. This is a missed opportunity, as statistical literacy is increasingly vital for informed citizenship and participation in a data-rich economy.

As the Smith report emphasises:, "the ability to analyse, interpret and present quantitative and statistical information and reason with data" is vital "to thrive in the modern workplace". The ability to interpret data, question claims and make evidence-based decisions is not only a key life skill but also highly valued by employers across sectors[134].

As the Royal Society has noted, we are living through a "data explosion", with fields like healthcare, climate science, and artificial intelligence increasingly driven by large datasets and complex modelling[135]. If the next generation is to be equipped to understand, critique and shape these developments, we accept the principle that we must give more authentic or complex data exploration a more prominent place in the curriculum. Additional specificity in the National Curriculum could move us towards a richer experience with real datasets, variation, interpretation and inference.

In practice: Data and uncertainty

Recommendation 1: Design a curriculum for mastery
A curriculum for mastery in data and uncertainty would be designed with cumulative progression, where fundamental knowledge is carefully sequenced and developed in increasing complexity through context-rich tasks. A vertical structure would allow core ideas like variability, representation, inference, and critical analysis to develop conceptually, not just procedurally.

What this progression might look like:

Phase	Conceptual focus	Mastery indicators	Example activities
KS1 (Y1 to Y2)	Pictograms, tally charts, Simple comparisons.	Describe what is shown, count and represent, spot the most/least.	Use classroom surveys (e.g. favourite fruit) to make pictograms and talk about what is most popular.
Lower KS2 (Y3 to Y4)	Bar charts, introduction to variability and fairness.	Begin to compare groups, recognise unequal group sizes, talk about results not being exact.	Create bar charts from data collected in a PE activity (e.g. number of skips in 30 secs) and talk about differences.
Upper KS2 (Y5 to Y6)	Mean as a measure of centre, line graphs, introduction to bias and sample.	Explain average, describe trends, begin to question reliability.	Analyse data from weather over a week, compare with another city, discuss if one week is enough to say if it is "wetter".
KS3 (Y7 to Y9)	Sampling, bias, interpreting uncertainty, correlation vs causation, digital data tools.	Plan investigations, explain limitations, use spreadsheets, interpret scatter graphs, critique data use.	Use datasets from UK government (e.g. crime rates) in spreadsheets to create charts, identify patterns, and discuss claims.
KS4 (Y10 to Y11)	Critical statistical thinking, real-world data analysis, uncertainty interpretation.	Evaluate sources, model uncertainty, compare distributions, challenge media claims.	Analyse COVID-19 datasets: calculate rates, compare regions, discuss sampling, bias, correlation/causation claims

Recommendation 2: Rebalance content from upper primary to lower secondary
By waiting until fundamental knowledge from the number and shape and space sub-domains are secure, the introduction of data and uncertainty content such as constructing and reading graphs can be much more efficient. Delaying the introduction of constructing and reading pie charts from KS2 to KS3, for example, would enable pie charts to be a context in which students could apply and deepen their knowledge of drawing and measuring angles, and calculating with fractions and percentages.

Recommendation 3: Increase the rigour of reasoning and problem solving
Statistical reasoning should go beyond finding averages or plotting graphs. Key statistical thinking (e.g. sampling, data reliability and using technology) should be introduced in upper primary to allow students to build deeper familiarity over time. With early exposure, these topics become part of students' conceptual toolkit, not novel ideas at GCSE. For example:

- Introduce sampling at Year 5 using practical tasks: "If we want to know students' favourite packed lunch, do we need to ask the whole school?"
- Introduce digital data tools (e.g. spreadsheets) at Year 6 to support graph creation and analysis: a basic Google Sheets activity on temperature trends.
- Introduce discussion of bias and fairness in Year 6 through exploration of question wording and who was included in a sample.

Tasks should explicitly develop problem solving and reasoning across these dimensions:

a. Interpretation and critique tasks
Example (KS3): "A headline says: 'Eating more oranges leads to better school grades!' The article shows a graph with a weak upward trend. What questions would you ask? What might explain this trend other than a causal relationship?"
Include tasks where students must interpret or evaluate data claims, especially from real-world contexts (media, policy, etc.).

b. Data collection planning
Example (KS3): "Plan how to investigate whether students at your school get more sleep on weekends. Think about: how to collect responses, possible biases, and how to summarise the data."
Students should engage in full data cycles – posing questions, planning how to collect data, and then interpreting it.

c. Uncertainty and variability
Example (KS2): "Here are the jump distances for two classes. One has a higher mean but also more variation. Which class is 'better' at long jump? Does it depend what we mean by 'better'?"
Encourage reasoning about *variability*, rather than just calculating an answer.

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