The Public attitude to maths and maths education

Charlie Stripp MBE - MA President 2024-2025

In my first Presidential report for Mathematical Angles, I set out three challenges that I think we need to address to improve maths education in the UK:

- Negative public attitudes to maths and maths education
- Chronic shortage of secondary and post-16 mathematics teachers
- Poor track record of using technology to enhance teaching and learning in mathematics

In this President's report, I explore the first of these challenges.

Maths is both beautiful and useful, and I believe the key to improving public attitudes to maths and maths education is to teach maths in a way that enables young people to appreciate both its beauty and its utility.

Public attitudes to maths

Usefulness of maths

On the utility side, I'd argue that public understanding of the utility of maths has probably never been greater. Over my career in maths education, I think public attitudes towards the usefulness of maths to society have improved significantly. People appreciate that the massive advances in technology, communications and use of data since the 1980s have been made possible by advances in computing and data science, and that computing and data science are underpinned by mathematics. There is also a growing awareness that mathematical models are vital tools to help meet major global challenges – mathematical models were in the news throughout the Covid-19 pandemic, and are frequently referred to in the media in the context of climate change.

Public attitudes to maths as an important tool for society are positive, but appreciation of the power of maths to support technological advances and help tackle major global challenges does not indicate an appreciation of the beauty of maths, nor does it mean people have a positive attitude to maths education.

Individual confidence with using maths

Data on attitudes to maths from a recently published Axiom Maths report, *Maths education in England 2023 – 24: Attainment and attitudes*[1], contradicts the view that people in the UK feel it is acceptable (or even a badge of honour) to say that they 'can't do maths', while they'd never boast about not being able to read or write proficiently. I've used this cliché about UK attitudes to maths myself in the past but in the light of the evidence from the Axiom report, and from what I see in schools and colleges and from speaking to teachers and students, I won't use it in the future. I think this view has become a lazy cliché. It may have been true once, but not anymore. The Axiom research suggests that people know that maths is important in their lives and most feel they can use maths with confidence. That some people in our society feel intimidated by maths and are not confident using it, reflects a problem with our maths education system. As I outline in this report, I believe that the way maths is taught in England is improving, though the chronic shortage of secondary mathematics teachers (the second challenge I highlighted in my first presidential report) is limiting progress.

Public attitudes to maths education

Misconceptions about maths 'ability'

There is a persistent misconception in our society that maths ability is 'fixed', and that some people (a minority) can 'do' maths and others can't – just about every teacher of maths will have heard a parent say something like: *'I'm not surprised X is struggling in maths, I was always rubbish at it myself'*. Such parental attitudes can lead some children to feel that there's no point in engaging with learning maths because they are, innately, not a 'maths person'.

Other cultures, notably those in Far Eastern countries that consistently outperform the rest of the world in international comparisons of maths education, do not hold this misconception, believing instead that effective teaching and hard work enable all to improve their mathematical ability.

As I discuss later in this report, I think we are now making progress in dispelling the myth that maths ability is fixed – hopefully future generations won't pass on this myth to their children!

Focus on assessment

The strong emphasis in our education system on high-stakes external exams fuels negative attitudes towards maths education. Everyone knows the importance of doing well in SATs at the end of primary school and of going on to achieve a grade 4 or above in GCSE Maths – a 'Level 2' pass. However, thinking success in maths exams is important is not the same as thinking maths education is important. The value of learning maths as an enjoyable, intellectually stimulating and empowering activity can be eclipsed by the focus on exams and the pressure to succeed, squeezing the joy out of learning. I sometimes ask students (and their parents) why they think it is important to study maths. Often the first answer they give focuses on the need to pass maths exams, not on the value of maths itself. Schools and maths teachers must take some responsibility for this. Success in external maths assessments features highly in school accountability measures, putting pressure on school leaders. Maths teachers feel that pressure and can transmit it to their students, and schools can distort the way maths is taught, so the main focus is on exam success, rather than on the value of learning mathematics - as Ofsted noted in its 2023 mathematics subject report, 'Coordinating mathematical success'[2]:

'The teaching of disparate skills to enable pupils to pass examinations but not equip them for the next stage of education, work and life, and weaknesses in the teaching of mathematical problem solving, remain areas of weakness across many schools.'

The same report also makes the important point that:

'Strong exam outcomes do not, necessarily, indicate a high-quality mathematics education because, in some schools, pupils are taught a narrowed curriculum that allows them to be successful in exams without securing the mathematical knowledge they need to be successful later. These decisions are made because leaders and teachers are acutely aware of the impact of pupils achieving certain threshold grades in terms of post-16 opportunities, and implications for school accountability.'

Despite my misgivings about exams, I think it is important to assess students' level of proficiency in maths at key transition points, to inform their progression to the next stage of their education and to ensure they are equipped to use maths effectively in their life and work. However, our current use of high-stakes external exams has serious flaws; it is intimidating and demotivating for many students and, as Ofsted points out, maths exam success can be achieved without a high-quality maths education. I think we need a review of maths assessment to see how these flaws might be overcome. I suspect a blend of continuous assessment, teacher assessment and terminal examinations, facilitated through appropriate use of technology, could improve things. Research and trialling will be needed to inform any changes.

Improving attitudes to maths education

Dispelling the misconception that some can do maths and some can't

A key, underpinning principle of the NCETM's 'Teaching for Mastery' (TfM) pedagogy, which is promoted throughout England through the Maths Hubs and supported by extensive, fully-funded professional development, states that *'Mathematics teaching for mastery assumes everyone can learn and enjoy mathematics'*[3]. Children are not labelled as being 'clever at maths' or as 'struggling with maths'. The aim is for schools to develop a maths learning culture where their students are engaging

with the teacher and with one another to learn maths together. Teachers who adopt this attitude towards their students' maths potential and combine it with the overall TfM pedagogy, report that it results in positive attitudes towards maths from all children – they engage with learning maths and feel empowered by their learning. Teacher feedback suggests this narrows maths attainment gaps and improves mathematical learning for all.

Teaching for mastery

TfM encourages students to engage with structure and connections within maths. More time is spent supporting students to develop fluency with fundamental mathematical ideas like additive and multiplicative reasoning - ideas and concepts that enable students to see how maths 'makes sense', rather than rushing through the curriculum teaching rules and tricks to get 'the answer' without really knowing why. As part of this, it supports students to learn number bonds, times tables and other key mathematical facts to automaticity, to avoid cognitive overload in working memory and enable pupils to focus on new learning with confidence. Developing firm foundations of fundamental ideas leads to rapid progress later. Careful questioning - not just *'What's the answer?'*, but also *'How did you work that out?'* and *'Why did that work?'* is used to encourage students to articulate their understanding, reinforcing connections and stimulating deeper thinking, so making learning more secure.

These examples, one from KS1/2 and the other from KS3, illustrate the idea:

Example 1: Relationships between addition and subtraction

Addition and subtraction are taught in parallel, using manipulatives to emphasise the structural relationship between the two operations. Teaching in this way highlights that if you know that, for example, $5 + 3 = 8$ then you also know that $3 + 5 = 8$, $8 - 5 = 3$ and $8 - 3 = 5$.

A similar approach is taken with multiplication and division

Example 2: Comparing fractions

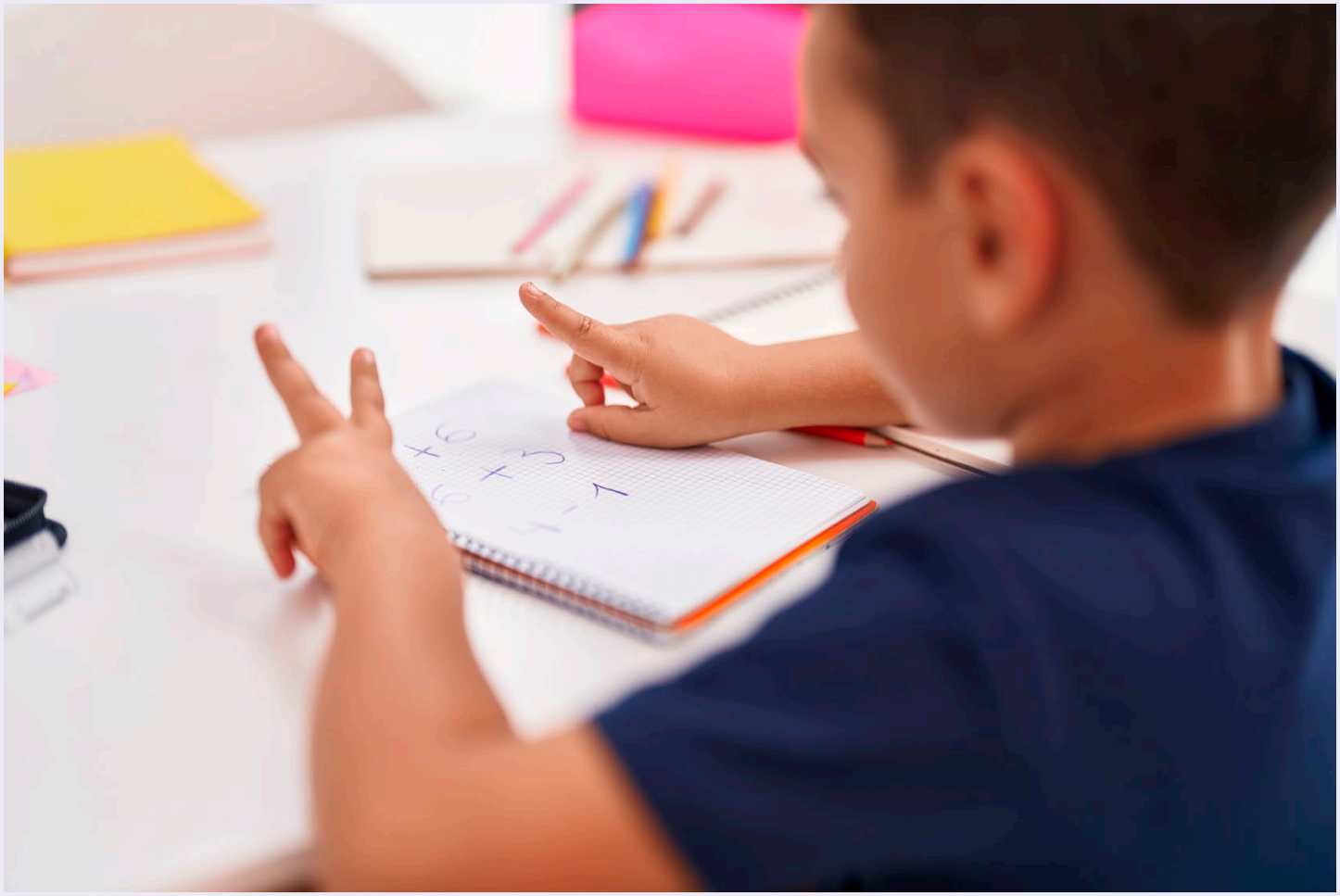
Rather than just resorting to the standard algorithm of finding a common denominator, then comparing the numerators (which is often learned by rote, rather than understood), students are encouraged to use their understanding of numbers and fractions to see if the comparison might be made more efficiently, e.g.

(a) What's bigger, 5/16 or 4/13?

One way to think about this is to see that both fractions are a bit less than 1/3, but that $3 \times 4/13$ is 1/13 away from 1, whereas $3 \times 5/16$ is 1/16 away from 1. Since 1/13 is bigger than 1/16, 5/16 must be bigger than 4/13. (Students would be asked to explain why they know that 1/13 is bigger than 1/16)

(b) What's bigger, 9/467 or 3/148?

Here, considering a common numerator helps: $3/148 = 9/444$, so 3/148 must be bigger than 9/467 because 9 divided by 444 must be bigger than 9 divided by 467. (Students would be asked



to explain why they know that dividing 9 by 441 must give a bigger answer than dividing 9 by 467)

I can't do justice to explaining TfM in this report. A detailed explanation can be found via the 'Mastery Explained'[4] section of the NCETM's website, see especially 'The Essence of Teaching for Mastery'; 'The Five Big Ideas'; the 'Professional Development Materials' and the DfE non-statutory guidance documents for the Mathematics National Curriculum[5, 6], which were produced by the NCETM and reflect the TfM approach.

Fostering an appreciation of the beauty of maths

Every secondary school maths teacher has been asked *'What's the point of learning this?'*, often by a student who is struggling with a particular aspect of the curriculum. These are a few possible answers to this question:

1. Because it helps to develop your ability to think and reason and make sense of things[7].
2. Because you'll need it to enable you to understand some more sophisticated maths that you will learn about later on.
3. Because it will help you to solve problems you might encounter in life and work.
4. Because it's likely to come up on the exam.

I think the first two are good answers, but not all students will be convinced by them – they are quite abstract. The third and fourth answers are more compelling for students but, for most people, the third answer will only apply to some aspects of the curriculum. Teachers often resort to *'Because it's likely to come up on the exam'*. This is concrete and easy for the student to identify with, but reinforces the view that the purpose of maths education is all about the assessment, which we know is demotivating for many students.

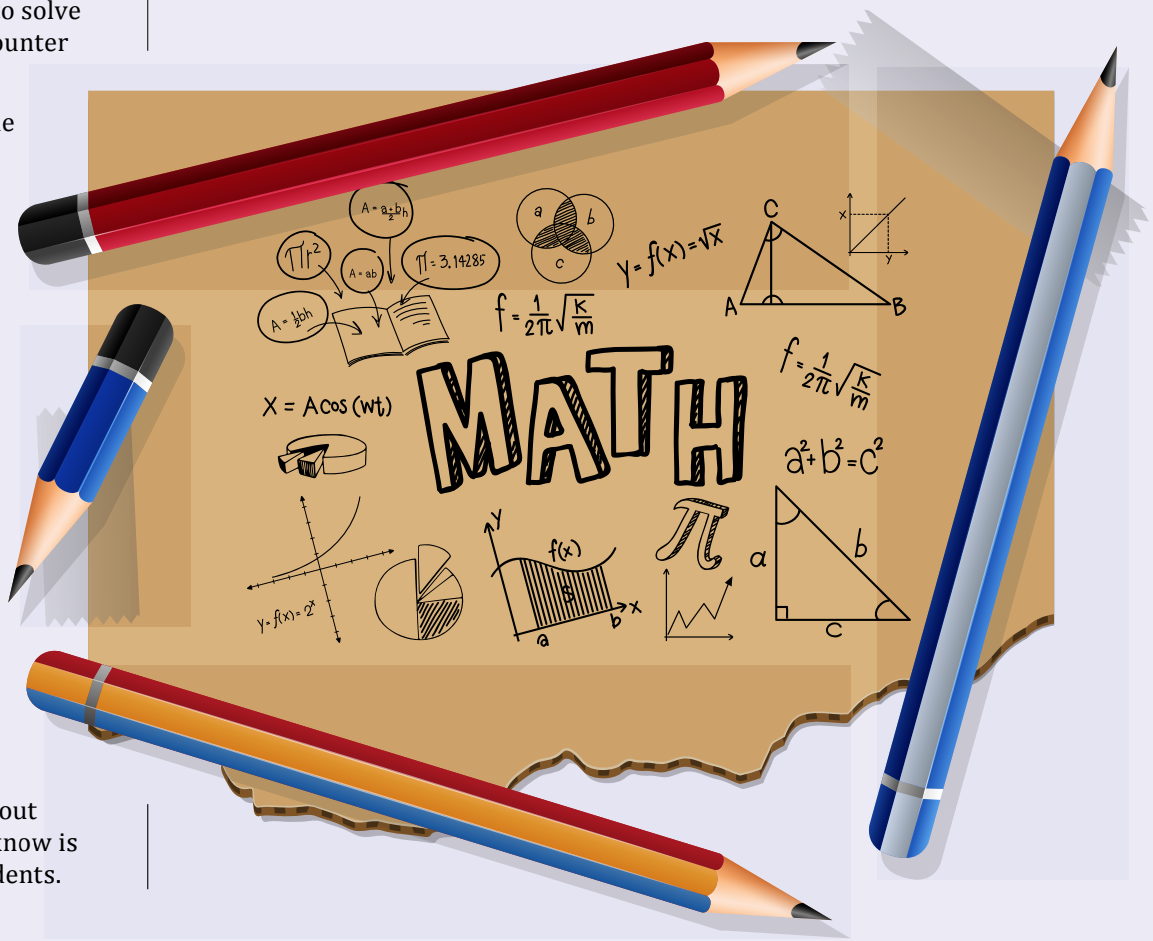
I think the best answer is *'Because maths is a beautiful subject and learning maths and using it to solve problems is hugely satisfying and enjoyable'*, but a student who is asking the 'What's the point?' question probably wouldn't agree!

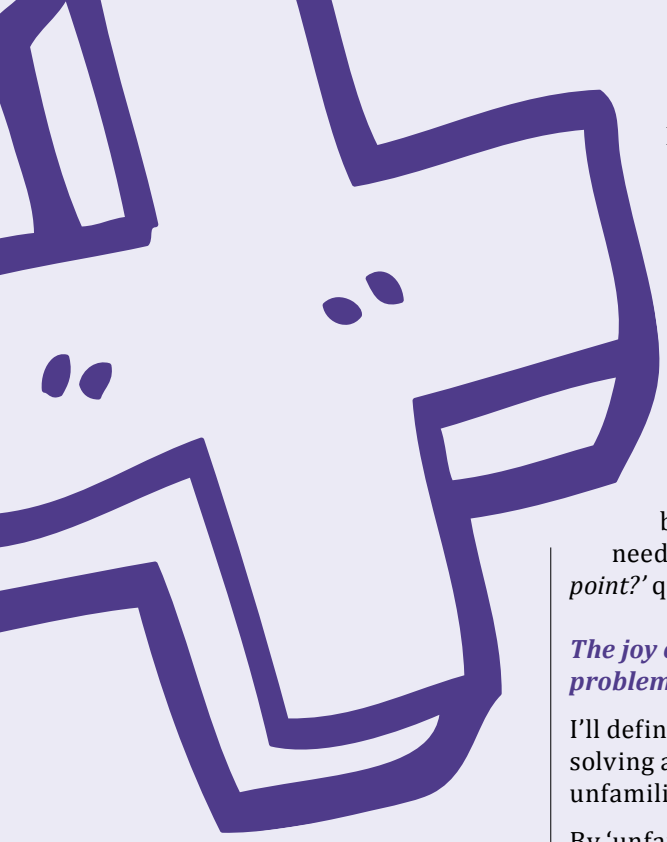
I'd like everyone to appreciate the beauty of maths, and believe everyone can. Not being able to appreciate beauty in maths is like not being able to appreciate music. Mathematical beauty is a source of pleasure and we owe it to students to help them to appreciate this beauty.

I'm interpreting 'beauty' in maths as the feeling you get when a piece of maths is particularly satisfying or elegant. This might be when a student has a 'light-bulb' moment and understands a concept or mathematical proof for the first time and can explain their reasoning, or when a problem has a particularly elegant solution, or when a piece of maths students are learning is particularly profound or surprising. Using this interpretation, I think every maths lesson can involve maths that can be considered 'beautiful', and students at all levels of attainment can appreciate the beauty of maths.

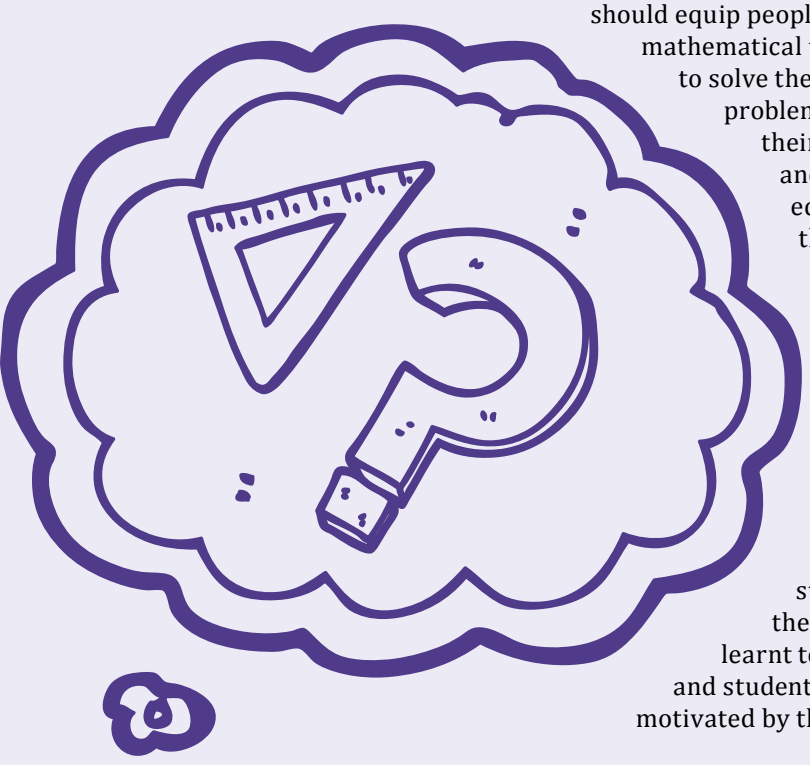
For example (you'll be able to think of many more):

- If a number is divisible by 6 it must also be divisible by 3 and 2 (Why?)
- The links between fractions, decimals and percentages
- X% of Y is equal to Y% of X (Why?)
- If I know two quantities, A and B, are proportional and I plot a graph of A against B I will get a straight line through the origin (Why? Why is this useful? What does the gradient of the line tell me?, ...)
- If you start from any point on the circumference of a circle and construct successive points on the circumference of that circle using arcs from one point to the next with the same radius as the circle, then join the points, you must get a regular hexagon (Why? How does this link to honeycombs?)
- Understanding that Pythagoras's theorem is true for all right-angled triangles (How do you know this for sure?)
- Understanding how trigonometric functions link to the unit circle and Pythagoras's theorem





- The completed square form of a quadratic and how it relates to is graph (Why does this form show immediately where the turning point is?)
- A neat solution to a problem, e.g. Is it possible to completely cover a disc with two other discs, both of which have a smaller radius than the disc being covered? If not, why not? (I'll leave you to think about this one)



I like maths teachers to point out 'beautiful' mathematics directly – this helps reinforce mathematical connections, helps students to appreciate mathematical generalisations and structure, and deepens their thinking and understanding. If students learn to appreciate the beauty of maths, they will be less likely to feel the need to ask the *'What's the point?'* question.

The joy of mathematical problem solving

I'll define mathematical problem solving as using maths to solve unfamiliar, unstructured problems.

By 'unfamiliar' I mean problems that a student hasn't been specifically trained to solve; by 'unstructured' I mean that the student is not told what maths to use and must decide the solution steps themselves.

Answering some of the questions on GCSE and A level maths exams (mainly those aimed at the highest attainers) requires students to do this type of problem solving.

The key purpose of maths education should be to enable people to use maths to solve problems in life and work, not to learn how to answer exam questions. Maths education should equip people with the mathematical tools they need to solve the mathematical problems they meet in their work and life and, crucially, also equip them with the knowledge of how to apply those tools flexibly to solve the problem. The post-16 'Core Maths' qualifications focus specifically on teaching students to apply the maths they have learnt to real problems, and students are very motivated by this[8].

I like the analogy that mastering mathematical techniques is like learning musical scales, and using the techniques to reason, solve problems and develop new insights is like making music. Mastering techniques is crucial, and can be very satisfying, but the greatest pleasure in maths comes from reasoning, problem solving and developing deep understanding. Mathematical problems pitched at the appropriate level are motivating for students – they want to know and understand – they can see 'the point'. However, if students are not taught how to apply the maths they have learned to solve problems, asking them to solve problems is likely to have the opposite effect, making them feel they 'can't do maths'. Ofsted's 2023 'Coordinating mathematical success' report[9] has useful things to say about problem solving:

On the teaching of lower attaining pupils:

'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 mathematics.'

On good practice in teaching mathematical problem solving:

One department had clearly identified the range of problems that they wanted pupils to be able to solve at various stages of the curriculum. In lessons, teachers modelled how pupils could use new learning to solve mathematical problems. They drew out the mathematical similarities in a range of problems that, on the surface, looked unlinked. They gave pupils opportunities to practise solving problems of a mathematically similar nature.

Suitable problem solving questions should be integrated into the curriculum, rather than having separate 'problem solving' lessons or using problem solving as an extension task. Problem solving isn't separate from maths, it's the point of maths!

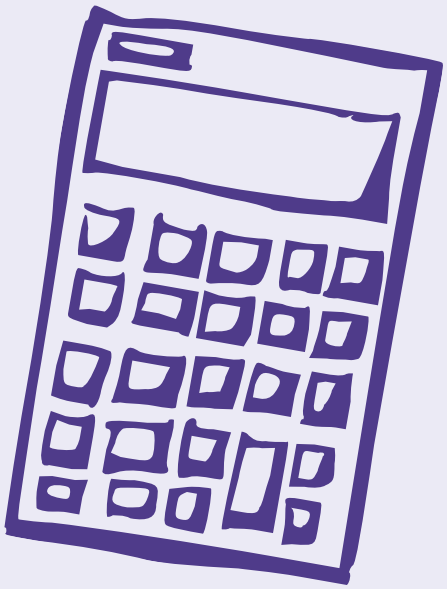
There are many excellent sources of mathematical problems that maths teachers can use to help embed problem solving into their school's or college's maths curriculum,

including the NRICH website[10], the MA's Primary Maths Challenge[11], the UKMT maths challenges[12] and, for A level Maths students, the MAT, TMUA and STEP university maths entrance tests[13]. Core Maths, suitable for all post-16 students who have achieved a Level 2 pass in GCSE Maths, is all about how to apply maths to make sense of real problems and all schools and colleges with post-16 provision should offer it[14].

Developing a classroom culture where students who view mathematical problem solving as an enjoyable challenge, rather than something hard and intimidating is the aim: *'Problems worthy of attack, prove their worth by fighting back!'* (Piet Hein). The key is to pitch problems at the right level for students to experience both the thrill of the struggle and the joy of success.

The role of curriculum, qualifications and assessment

I mentioned earlier the damaging effect that the current assessment regime has on public attitudes to maths education. There should be a review of the maths curriculum and qualifications that takes account of students' attitudes and motivation. The following points would inform that review:



- The current way the KS3/4 curriculum is assessed means grade boundaries are low - students can achieve a 'Level 2' pass' in GCSE Maths with a score of less than 25%[15]. This undermines many students' confidence in their ability to do maths, deterring many from choosing to study maths post-16 and reinforces a view that it is only passing the exam that matters. Summative assessments could and should enable students to demonstrate what they can do, not highlight what they can't.
- Technology is playing an ever-increasing role in our lives and in how maths is used in life and work, yet the current curriculum takes little or no account of this and so makes maths seem less relevant – the work of the Royal Society's 'Mathematical Futures' programme[16] and MEI's work on the maths curriculum[17] and on data science education[18] can help point the way forward.
- The current GCSE resit regime, despite the valiant efforts of FE teachers, is not fit for purpose and turns many young people off maths, reinforcing negative attitudes to maths education. MEI's work with the Nuffield Foundation[19] suggests there could be a better curriculum and assessment regime for these students.
- Now that it is the norm for students to continue in education to at least age 18, the requirement that all must take GCSE Maths at age 16 is unnecessary. Teachers and students know that many are not ready to achieve a 'pass' at age 16. Current practice sets these students up to fail and is highly demotivating.
- Currently, external assessments in maths are marked against rigid mark schemes. This requires questions to be 'closed', restricting the types of questions that can be asked. This limits the assessment of problem solving and mathematical modelling. Could 'comparative judgement' marking[20] (whereby answers are expertly compared and then ranked algorithmically) enable more relevant and realistic (and so more motivating) questions to be used for some aspects of maths assessment?

Concluding comments

Public attitudes to the value of maths are more positive than they've ever been; people recognise the importance of maths for society and to help meet global challenges and most feel confident to use maths in work and life.

Attitudes to maths education are less positive. Significant progress is being made in improving how maths is taught, but the current over-emphasis on high-stakes assessment distorts teaching and is intimidating and de-motivating for many students.

Public attitudes to maths education could be improved by teaching in ways that highlight both the beauty and utility of maths, reducing the emphasis on high-stakes terminal assessment and incorporating more use of technology into the curriculum and assessment of maths.

Progress on improving public attitudes to maths education will be limited unless we can address the chronic shortage of secondary mathematics teachers.

Endnotes

1 1700-Axiom-Report_july24_p3.pdf (axiommaths.com)
2 Coordinating mathematical success: the mathematics subject report - GOV.UK (www.gov.uk)
3 The Essence of Mathematics Teaching for Mastery | NCETM
4 Mastery Explained | NCETM
5 Teaching mathematics in primary schools - GOV.UK (www.gov.uk)
6 Teaching mathematics at key stage 3 - GOV.UK (www.gov.uk)
7 Lack of maths education negatively affects adolescent brain and cognitive development | University of Oxford
8 What is Core Maths? - AMSP
9 Coordinating mathematical success: the mathematics subject report - GOV.UK (www.gov.uk)
10 NRICH (maths.org)
11 Primary Maths Challenge - Primary Mathematics Challenge
12 Home - UKMT
13 University maths entrance tests | NCETM
14 Offering Core Maths - AMSP
15 Curriculum and assessment in mathematics in England at KS4 and KS5 - MEI
16 Mathematical Futures programme | Royal Society
17 Curriculum and assessment in mathematics in England at KS4 and KS5 - MEI
18 Introducing students and teachers to data science - MEI
19 Proposal for a new qualification to tackle GCSE maths resit failure - MEI
20 Comparative Judgement - Daisy Christodoulou