Article

The Five Big Ideas – Mathematical Thinking

What does mathematical thinking really mean in the primary classroom?

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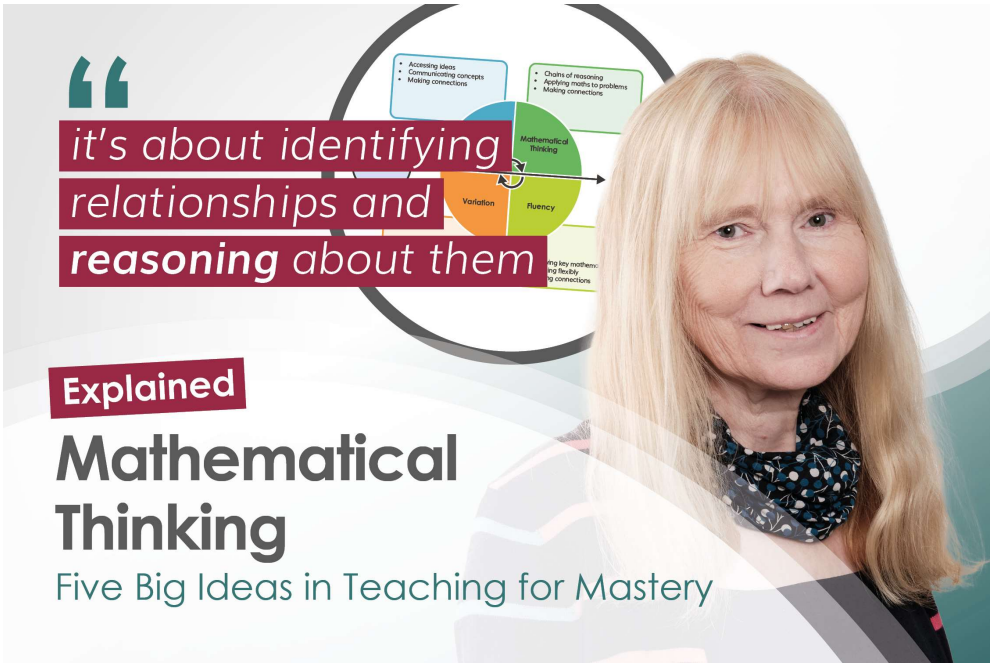


Dr Debbie Morgan, the NCETM's Director for Primary, answers all our questions about mathematical thinking in this Q&A feature. Learn about the different elements of mathematical thinking, the role of talk, and find out

Debbie's top tips for teachers. Find out more about the Five Big Ideas in Teaching for Mastery.

What do we mean by mathematical thinking?

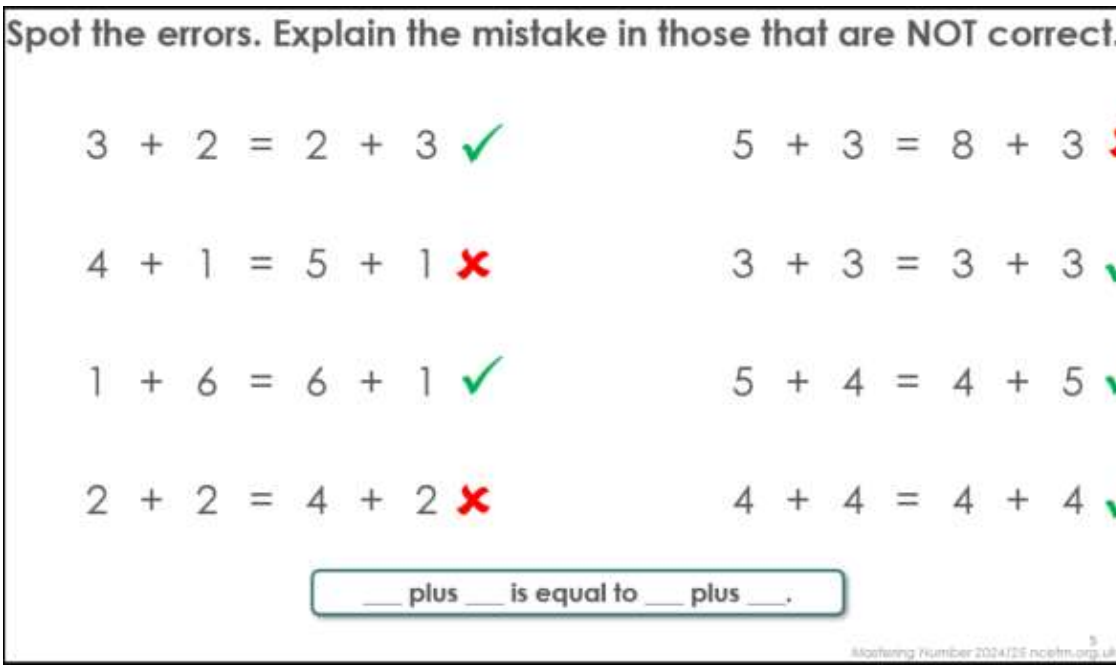
Mathematical thinking lies at the heart of learning mathematics. It is not a separate topic within the curriculum, but it's the foundation through which we understand and explore mathematical concepts. At its core, mathematical thinking is about identifying relationships and reasoning about them.

Unlike rules such as ''i' before 'e' except after 'c'', mathematical relationships are built on patterns and structures that we can teach pupils to make sense of, rather than simply memorise.

Engaging in mathematical thinking requires pupils to reason in different ways, including:

- **Describing** – articulating observations about numbers, patterns or relationships.
- **Explaining** – can pupils explain why an answer is incorrect? For example, why is $\frac{1}{4} + \frac{2}{4}$ not $\frac{3}{8}$?
- **Conjecturing –** making predictions and exploring possibilities. For example, if I double the number of apples, will I always get an even number?
- **Generalising** – identifying patterns and forming broader mathematical rules.
- **Justifying** – providing logical reasoning to support an answer or conclusion.
- **Proving** – demonstrating why the maths works through clear reasoning.

A great way to develop reasoning skills is through true or false activities, where pupils explain their thinking. Here is an activity on commutativity:



Without even calculating, we can reason that the second equation cannot be correct as both sides contain + 1, but 5 is greater than 4, so the totals must be different.

Whatever topic we are teaching, we are always guiding pupils toward a generalisation – a rule that always works. For example, when swapping factors in a multiplication equation, the product remains the same (e.g., $3 \times 4 = 4 \times 3$). Understanding why this works is key, but generalisations bring mathematical ideas together, making learning more efficient and meaningful.

How does it fit into the Five Big Ideas?

Mathematical thinking runs through all the Five Big Ideas – it is the thread that connects them.

- It is central to coherence and variation, as we journey through the maths we need to make sense of it.
- It supports fluency by helping pupils reason about known facts. For example, if 10×5 is 50, then 9×5 must be 5 less.
- It is essential to representation and structure. Children's mathematical thinking is engaged as mathematical structures are exposed.

What is the role of talk in the process of mathematical thinking?

Teaching maths is not just about telling – it requires engaging children in mathematical thought. However, it is also not an open-

ended process where children explore random ideas, some relevant and some not.

The teacher's role is to guide this thinking by focusing pupils on key mathematical elements that are crucial for their progress. Keeping this focus clear ensures that all pupils are reasoning about the same essential concept, helping them build a deep and connected understanding.

In the following video, note how the teacher supports the children's mathematical thinking to reason about the structure of the five times table, why 9 × 5 must be an odd number and less than 50. Listen to the children's explanations as the teacher draws this out.

Talk supports mathematical thinking and enables children to verbalise their thinking, which helps them to clarify and extend ideas. The role of talk is to provide the opportunity to communicate with precision. Communicating mathematical thought is an important part of mastering maths – as the adage goes, if you've truly mastered something, you can communicate it to someone else.

Some children feel less confident in speaking and expressing their mathematical thought but there are strategies that can help:

'Think, pair, share'
'Think, pair, share' is a staged approach that slows children down and gives them time for thought. First, children are given thinking time before talking – it's not a race to be the first with their hand up. Then they might verbalise their

thoughts to themselves by either talking to their hand or cupping their hand around their mouth. This gives them chance to rehearse what they are going to say. The next stage is speaking to their learning partner before having the opportunity to share with the rest of the class. What is important here is not just the talk, but children listening to the mathematical thinking of others and either being able to challenge or build upon it.

Stem sentences
Using stem sentences ensure the language is focused and levels the playing field for all children to be able to express their mathematical thought. They capture the maths and, as stem sentences are built into lessons, they become part of children's own thoughts and communication.

However, if used in the wrong ways, stem sentences can become just repetition without much thought. Ensure that children are not just parroting, but they are engaged in mathematical thought as they say the stem sentences. This can be done through having concrete manipulators or images to focus their thinking. Also, stem sentences should not be shared at the start of a lesson – co-construct the sentences with children so what they are saying makes sense to them.

Examples of stem sentences are embedded in the Professional Development materials and Curriculum Prioritisation materials, and are always highlighted in bold.

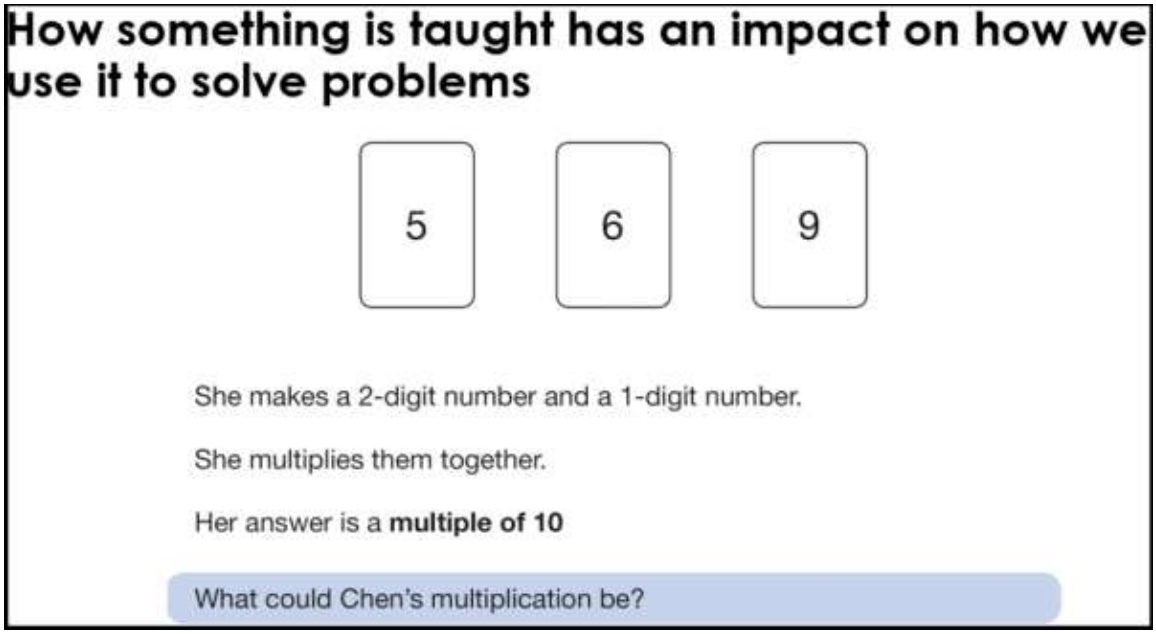
What is the benefit of considering mathematical thinking when designing maths lessons?

If the teacher plans for all children to think and ensures that all are thinking, then children will make better progress—it's as simple as that. It is also more likely that learning will be retained over time, as 'memory is the residue of thought' (Willingham, 2009). We remember what we think about, which is why it is so important that the teacher focuses pupils' thinking, because that is where learning takes place.
There is sometimes a danger that only some children in the class do the thinking and the others opt out, but we need to ensure all children are involved.

What are some of the challenges teachers might face?

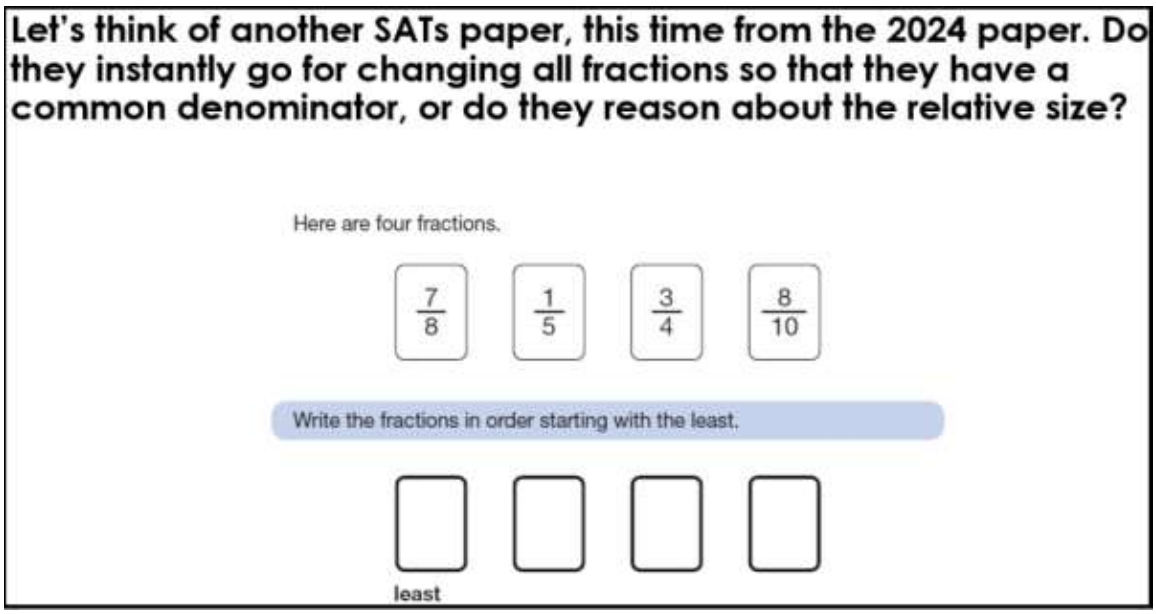
A key challenge is ensuring that all children understand what it means to learn mathematics. Teachers need make it clear to children that maths is not a passive process, where they just listen to the teacher and try to remember what they say. If children know that in every lesson we are seeking to make sense of the maths, their thinking process will be switched on. They will be looking for connections, spotting relationships and being mathematically observant.

How might your pupils answer this SATs question?



Do they dive in and randomly position the digits then start multiplying to see if they end up with a number that ends in a zero (i.e. is a multiple of 10)? Or do they think carefully about the structures and relationships between numbers that will make it a multiple of 10? How we teach the maths has huge implications on how children think about what it means to be a mathematician.

Here is another example SATs question:



Some children might automatically start to turn them all into an equivalent fraction that has the same denominator. However, if children have been taught to stop and think about what they notice before launching into a procedure, they will hopefully see that $\frac{1}{5}$ must be the smallest fraction as all the others are over $\frac{1}{2}$.

What are your top tips for teachers who want to improve pupils' engagement in mathematical thinking?

Focus on all children's thinking and make sure that they are all thinking about the essential element of the mathematics that you are trying to teach.

Mathematical thinking and reasoning are not add-ons—they are the way that we learn maths. Reasoning isn't an individual task, so ensure that pupils are given the opportunity to reason throughout each lesson.

Oracy is crucial in the process of mathematical thinking, but children do not automatically become mathematical talkers. Children need to verbalise their thinking to make sense of it and it helps them to embed and extend what they are thinking. However, they need to be taught how to do this. Maths Hubs offer a range of fully-funded professional development opportunities to support teachers to develop effective teaching strategies, such as the 'think, pair, share' structure.

Keep any eye out for our explainer video coming soon, *What does mathematical thinking really mean in the primary classroom?*

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