Sheard, Simon (2026) Reasoned Choices: Teachers' Decision-Making About Manipulatives Through a Maths Mastery Lens. In: British Congress of Mathematics Education 10, 23-24 Oct 2026, University of Nottingham.

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AQA
Questions matter

MATHS HORIZONS

Reasoned Choices: Teachers' Decision-Making About Manipulatives Through a Maths Mastery Lens

Simon Sheard

BCME British Congress of Mathematics Education

Sixth year of part-time PhD:

How do primary mathematics teachers' perceptions of Teaching for Mastery (TfM) inform their choices when selecting and using manipulatives (concrete resources) within their lessons?

University of Sunderland

130 questionnaires

14 interviews

descriptive statistics

thematic analysis

13 questionnaire respondents (10%) said they do not use manipulatives

Not encouraged to do so by curriculum lead

I teach Y6, so I generally use visual to support learning

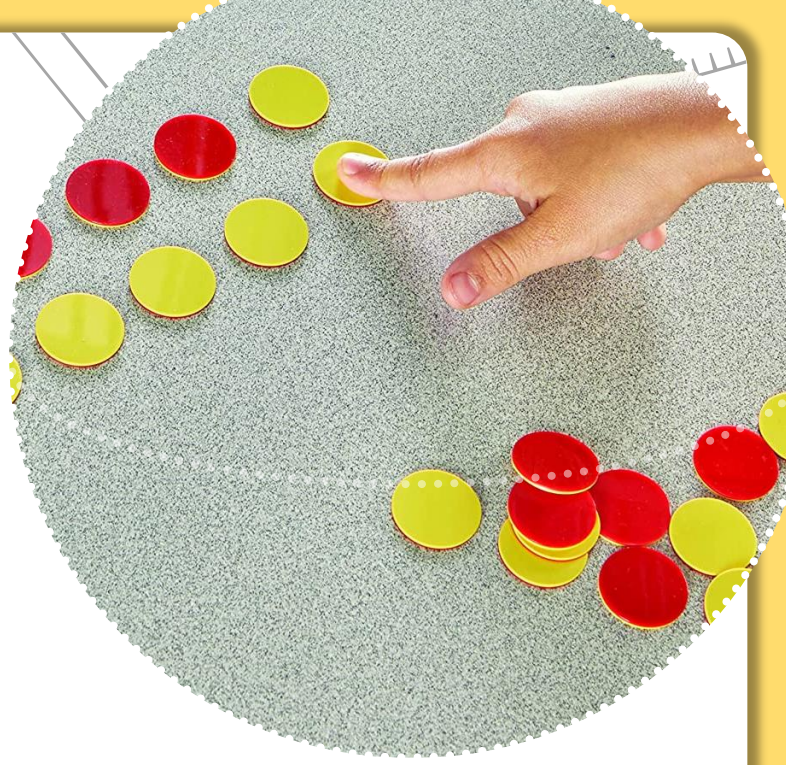
I do use some but usually for demonstration purposes

There is an issue of resources

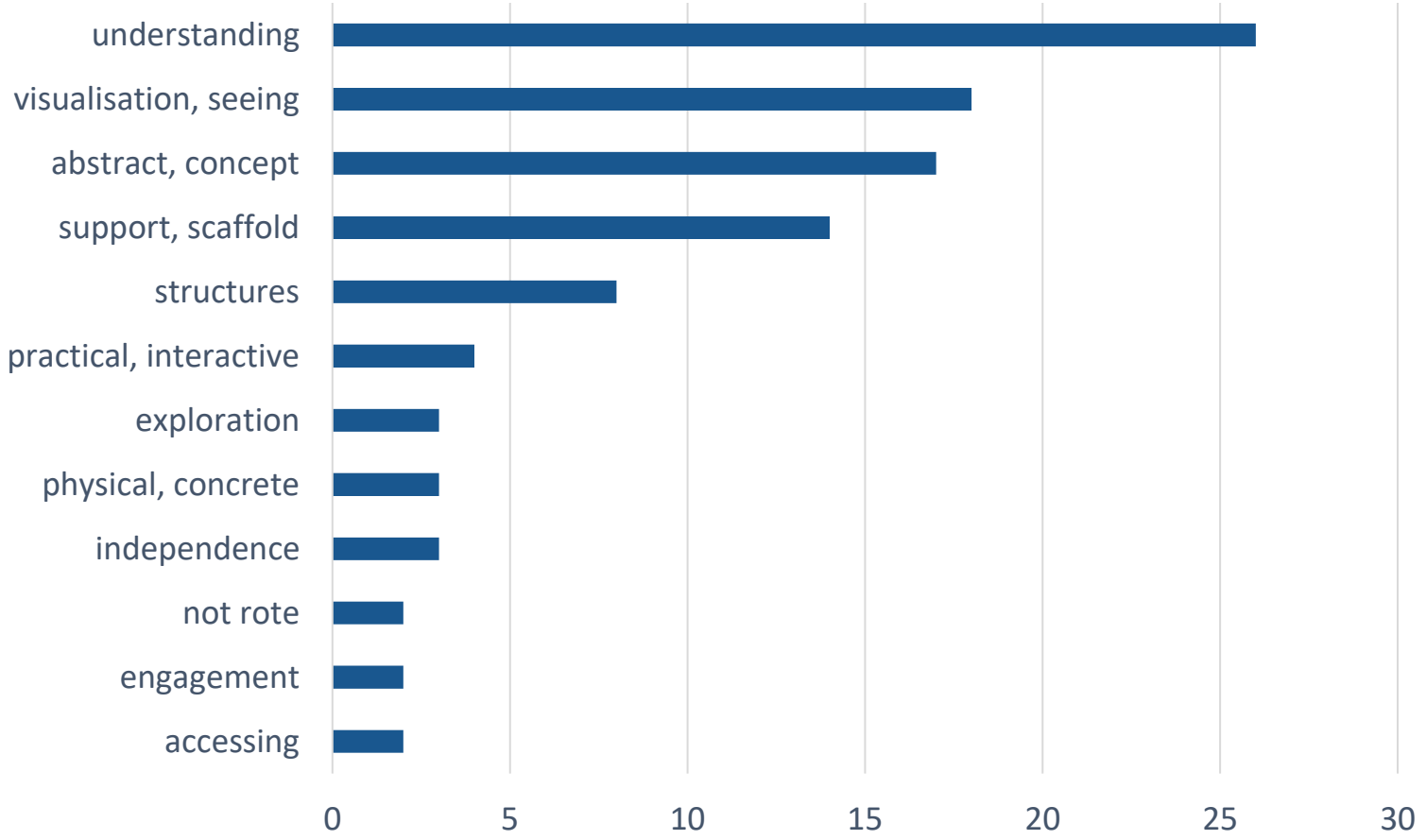
I do demonstrate with manipulations but I do not give them out to the pupils. The pupils tend to get distracted

Which manipulatives are used and how often?

Manipulative	Mean
interlocking cubes, e.g. multilink	4.14
two-sided counters	4.11
Dienes/base ten	3.76
Numicon	3.67
place value counters	3.66
Rekenrek/abacus	3.15
bead strings	3.04
sticks, e.g. lolly sticks	3.01
Cuisenaire rods	2.68
fraction tiles	2.32
algebra tiles	1.94



I use manipulatives in my maths lessons because...



single references:

problem solving; assessment; modelling; progress; inclusion; communication; connections; knowledge; demonstrate

TEN THEMES FROM ANALYSIS

- Accessibility and inclusion
- Choice and preference
- Cognitive processes and understanding
- Concrete-Pictorial-Abstract (CPA)
- Continuing Professional Development (CPD)
- Developing the whole child
- Notions of TfM and 5 Big Ideas
- Pedagogy
- Potential limiting factors
- Schemes

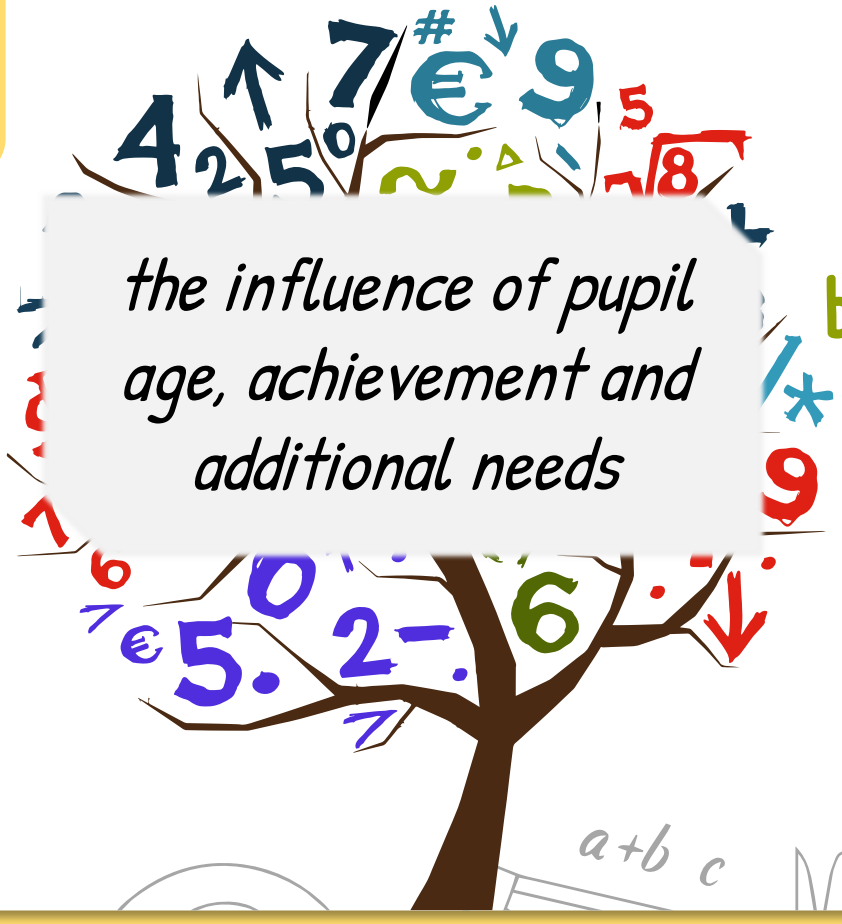
THEME 1: ACCESSIBILITY & INCLUSION

small steps

Mastery for me is where all children are given the opportunity to learn the smaller steps and how they build up (IR9)

'hook' for new concepts

I think it draws them into a lesson very, very well, so I immediately have them hooked if I have things out on the table (IR8)



the influence of pupil age, achievement and additional needs

achieve together

NCETM (2016) 'Essence of Mastery' – all pupils work together on the same lesson content

beneficial for pupil groups

- SEND
- EAL
- EYFS
- Lower achievers

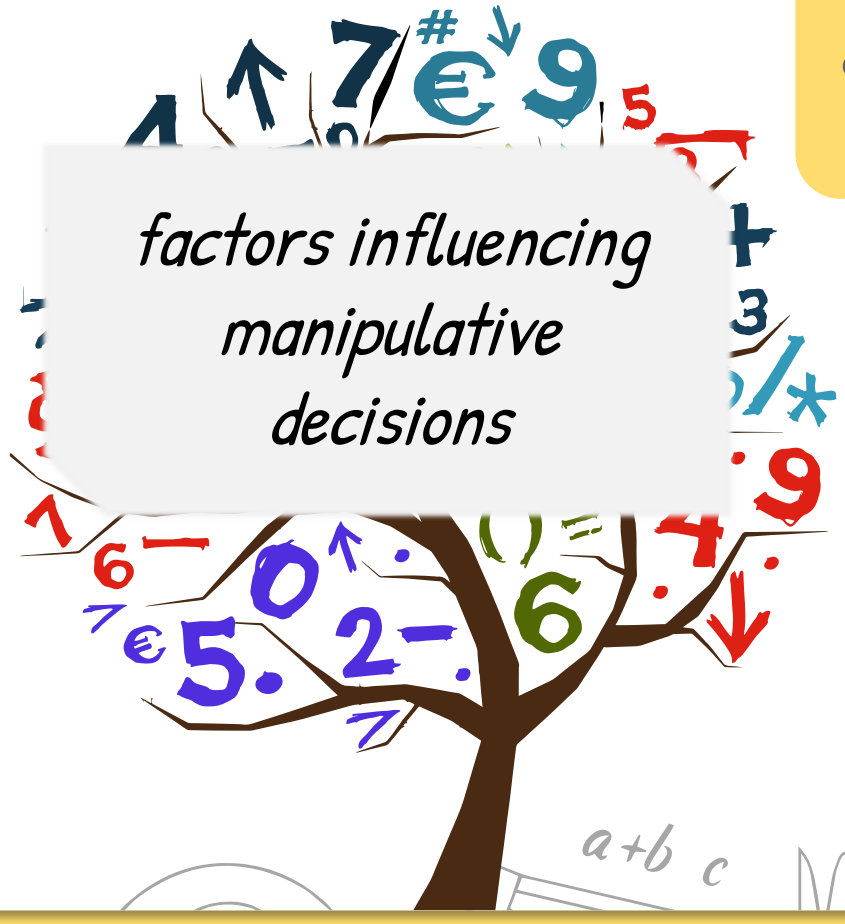
THEME 2: CHOICE & PREFERENCE

curriculum objectives

'we have a tendency to adopt different representations and artefacts depending on their suitability for a specific bit of mathematics' (Back, 2013, p.1)

ease of use

[Dienes] are just easy. They're there. They can grab them. The children are quite happy to use them. They don't take any preparation, really. They're just great (IR7)



factors influencing manipulative decisions

maths topics

You could argue that we use manipulatives more now to teach calculations than other things like number system work (IR5)

versatility

I like counters. I think you can use them in a variety of ways and I think I like the idea of being able to give things different values (IR14)

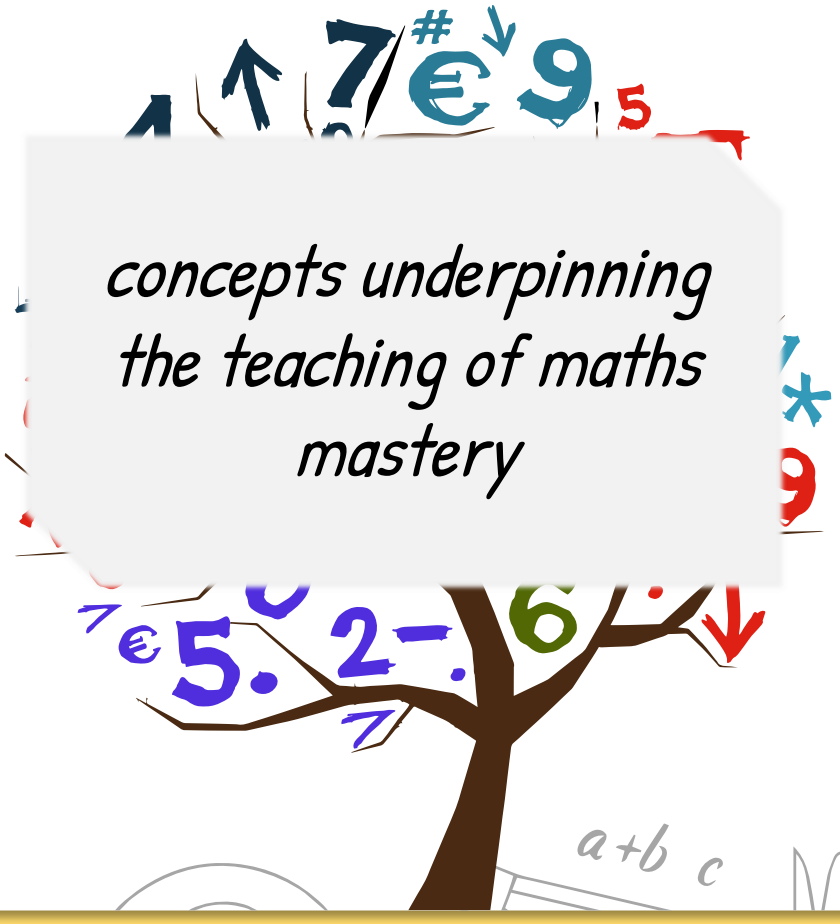
THEME 3: COGNITIVE PROCESSES & UNDERSTANDING

retention, memory & consolidation

I think [the concept] is easier for them to grasp, but also sort of works with their different type of memory because they're using a different scale of physically doing something (IR13)

making connections

Notions of cognitive constructivism



concepts underpinning the teaching of maths mastery

prior, new & transferable

[mastery is] being able to just to master a certain part of maths and use it in different ways, sort of being able to use a certain bit of knowledge elsewhere, knowing when to use it (IR11)

deep understanding

Fostering deep understanding as part of a mastery approach (Drury, 2014)

mental models

[manipulatives] allow students to develop a mental model (QR8)

THEME 4: CONCRETE-PICTORIAL-ABSTRACT (CPA)

perceptual richness

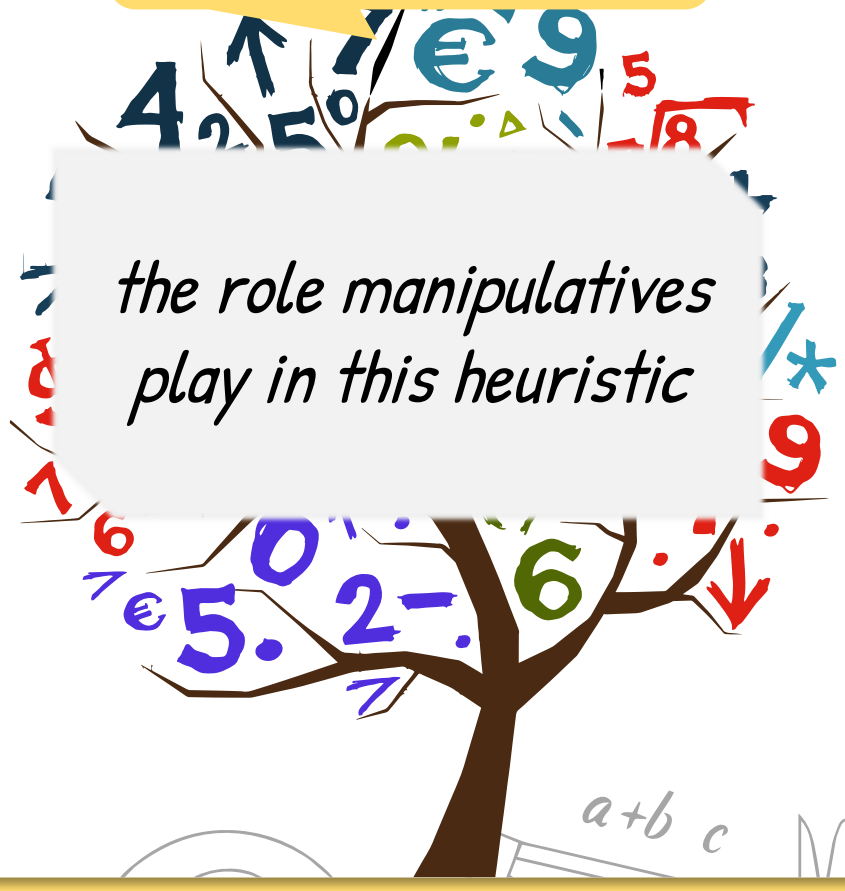
I think [counters] do have a place... but we tend to use more fun things (IR12)

finger counting & sense making

Using both fingers and manipulatives together during arithmetic is an effective way of offloading or externalising the cognitive load (Le et al., 2024)

notions of representation

Brunerian principles of enactive-iconic-symbolic



the role manipulatives play in this heuristic

transition to visualisation

I like it that they can physically use it, and then it's so quick and simple for them to draw (IR6)

abstract thinking

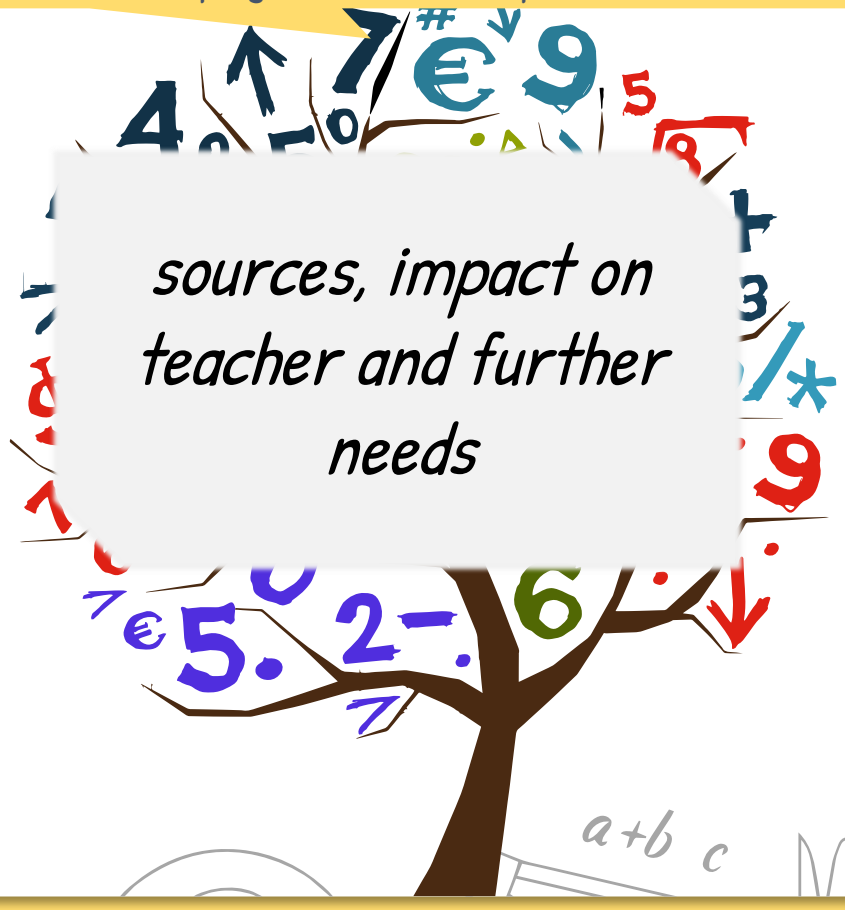
Notions of sense-making (Hoong, Kin & Pien, 2015)

THEME 5: CONTINUING PROFESSIONAL DEVELOPMENT (CPD)

facilitating CPD

'Teaching for mastery requires a solid base of mathematical pedagogical content knowledge...we have no problem with allowing a great number of teachers with little deep subject knowledge to teach maths to primary-age pupils' (Garry, 2020, pp. 2-17)

So there's the monitoring of the school systems, and there's also the coaching side of things through observing other teachers and helping them with their practise (IR5)



sources, impact on teacher and further needs

sources of CPD

- In-school
- Multi Academy Trust
- Local Authority
- Maths Hub
- Commercial provider

further CPD needs

I'm quite experienced in this year group. If I was to move to another year group... I would definitely need further training I think (IR12)

THEME 6: DEVELOPING THE WHOLE CHILD

independence & confidence

independent learning skills
↓
confident problem solving & reasoning

exploration & investigation

[manipulatives] allow just a bit of exploration, a bit of investigation (IR14)

the wider benefits of mastery and manipulatives

play & fun

I think the children prefer the more fun side to it. You know the colourful (IR12)

practical interactivity

children learn by doing and manipulatives are a great way to do that (QR102)

not rote learning

a tonic for didactic approaches?

[manipulatives] deepen their understanding, because they're physically doing it, they're not just listening to me talking (IR12)

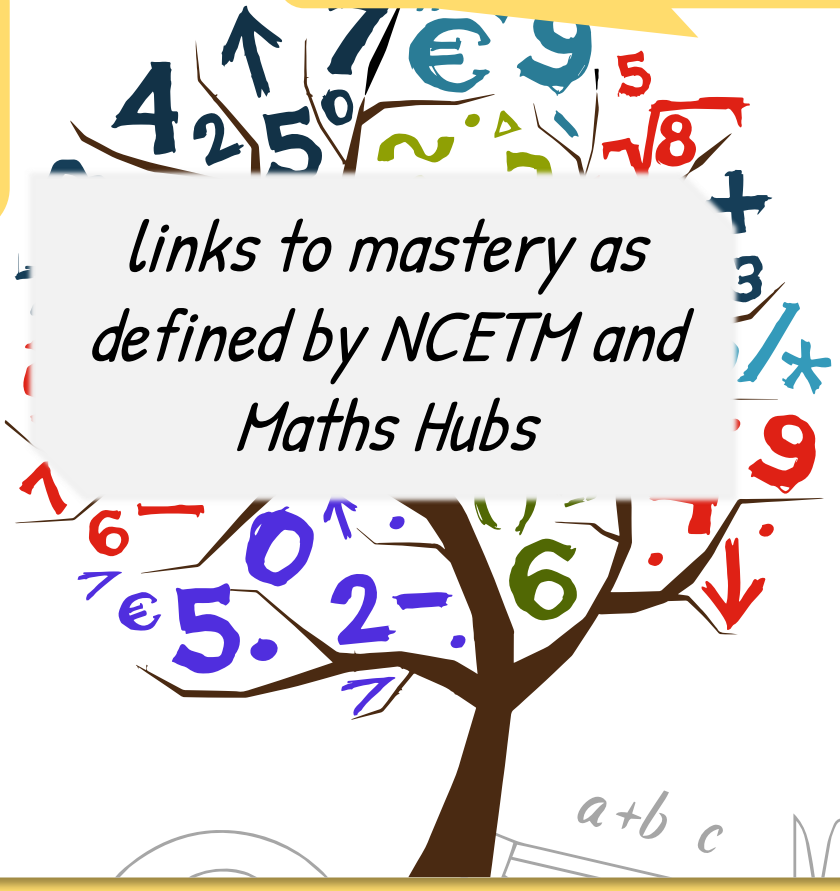
THEME 7: TEACHING FOR MASTERY (TfM) AND 5 BIG IDEAS

mathematical structures & thinking

[manipulatives] give me a different approach. Rather than just teaching on the board, it gets children to have that mathematical thinking (IR10)

fluency, reasoning & problem solving

[manipulatives provide] the pathway for reasoning and explanation that otherwise younger children often find difficult (QR108)



links to mastery as defined by NCETM and Maths Hubs

variation

Conceptual – how a concept is represented
Procedural – how students proceed through a learning sequence

mathematical understanding

Mathematical learning theories imply that using manipulatives can increase conceptual understanding (Griffiths, Back and Gifford, 2017)

dialogue & explanations

e.g. Meaningful Moments for Mathematical Talk (EEF, 2023): Promoting high-quality talk through purposeful, playful practice

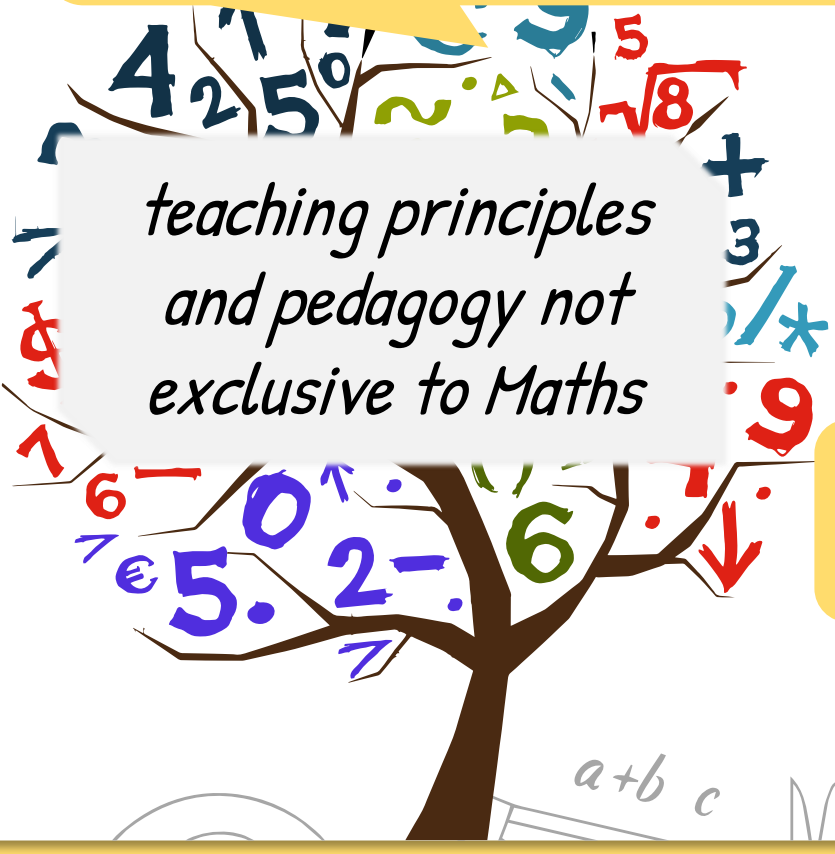
THEME 8: PEDAGOGY

assessment

[manipulatives are] really good assessment for learning. I can really clearly see what is going on in their head because it's on the table (IR7)

instruction, guidance & scaffolding

High level of instructional guidance?
Low level?
'Transitioning' level?



teaching principles and pedagogy not exclusive to Maths

stretch & challenge

For whom?
Challenging persistent stigmas

modelling

I use [manipulatives] in lessons at the start of a topic to model the method that they're going to be doing in their head. I think sometimes if you just throw words at the children, they really struggle to internalise what the method is (IR9)

pupil progress

[manipulatives] support, develop and deepen the understanding and progression of children (QR29)

THEME 9: POTENTIAL LIMITING FACTORS

preparation & organisation

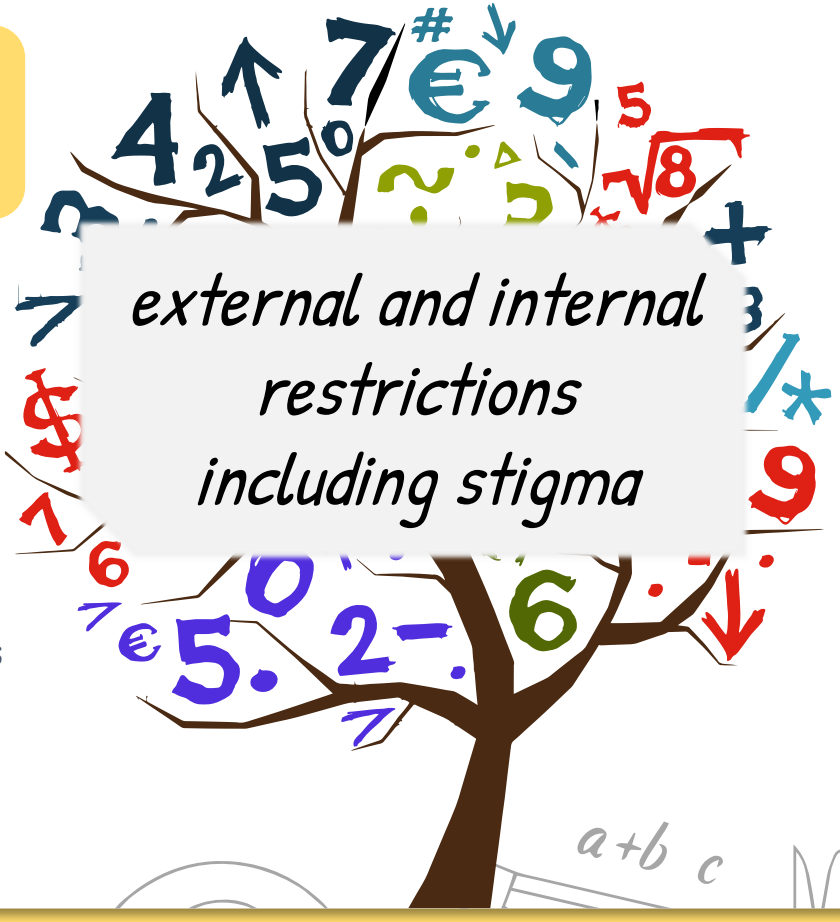
manipulative materials are found in every primary school but often in storerooms rather than classrooms (Swan *et al.*, 2007).

classroom management

I do not give [manipulatives] out to the pupils. They tend to get distracted (QR21)

age of learners

There's the pressure to get through the curriculum obviously in in time for the SATs. You do tend to find you don't have an awful lot of time to have those longer lessons featuring manipulatives (IR5)



external and internal restrictions including stigma

availability & cost

teachers' choice of manipulatives was subject to 'disparate factors' rather than pedagogical principles. The most influential factors were deemed to be 'almost accidental, depending on what was available or had been encountered' (Griffiths, Back and Gifford, 2017, p. 5).

'ability' of learners

there still is this stigma of, 'it's for your lower ability'. And I still think that is generally how people think in school (IR3)

THEME 10: SCHEMES

preparation & organisation

'Good lessons using manipulatives do not just happen. They are the product of much advance thought and preparation' (Stein and Bovalino, 2001, p. 359)

concrete or pictorial?

misconceptions around dual representation: pictorial representations in schemes to replace concrete resources

choice overload

when we originally used White Rose we found it was really broad. So within one lesson it would have five different versions of the same thing and that was just overwhelming for children (IR7)

how commercial and non-commercial schemes influence decisions

ease

How do you decide which manipulative(s) to use in a lesson?

That's quite an easy answer. It's directed by the by the Maths No Problem programme. It's quite precise. You know, you'll need this for this lesson (IR5)

off-the-shelf or adapted

I did encounter times where staff who weren't particularly confident teaching certain areas would deliver White Rose, but not really deal with the misconceptions or struggle to deepen the learning within lessons (IR5)

Findings

- Manipulative selection was driven by perceived pedagogical merit rather than TfM alone
- Teachers' understandings of TfM shaped how manipulatives were used rather than which manipulatives were chosen
- Multiple sources of CPD, including schemes and commercial materials, created differing manifestations of mastery-informed practice
- Persistent tensions and misconceptions continued to constrain mastery-informed manipulative use

What additional professional training would be of benefit to the sample group?

Recommendation 1 — Provide CPD opportunities dedicated to manipulatives

- Current manipulatives CPD is either localised or focuses on the use of a specific tool. Universal CPD that encourages teachers to weigh the relative merits of a wide range of manipulatives against mathematical objectives is needed.

Recommendation 2 — Extend CPD opportunities for non-subject leaders

- Teachers receive a significant amount of CPD from their subject leader in their role as a broker of professional learning. Direct access to prolonged training from specialists will improve PCK and increase the confidence of teachers who are not subject leaders.

Recommendation 3 — Map manipulative use across the curriculum

- Localised calculation policies include manipulatives but this is variable and focuses only on calculation. A wider-scoping resource that maps manipulatives to the National Curriculum programmes of study based on the pedagogical value of different tools would assist teachers in their decision-making process.

Recommendation 4 — Strengthen manipulative use outside of CPA

- Manipulatives are an effective part of the CPA heuristic but their value does not end there. Providing teachers with examples of discrete manipulative use to support specific aspects of fluency, reasoning and problem solving will broaden the depth and impact of manipulative use.

Practicality *vs.* Pedagogy

AVAILABILITY

What is available in my classroom? Are there sufficient sets for the groups/class? Is it cheap or expensive?

VERSATILITY

Can this manipulative be used for multiple applications? Or is it topic/task specific?

LOGISTICS

Is it ‘easy’ to administer and oversee?

Is it explained in the scheme of work?

CONTENT KNOWLEDGE

Do I understand how to use this manipulative?

PEDAGOGICAL CONTENT KNOWLEDGE

Am I confident instructing others how to use this manipulative for this task?

KNOWLEDGE CREATION

Is the manipulative driving the task?

Is the task driving the manipulative?

Preference?

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BERA blog

Questions

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CPD poster

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MATHS HORIZONS

Next up after Session 8

15:05-15:55	Session 9
16:00-17:00	Closing Plenary by Emily Farran Closing remarks by BCME chairs
17:00	Departure

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