Primary children's perspectives on the roles of reflection, explanation and challenge in 'mastery' resource-rich classrooms

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We report on English primary children's views on their mathematics learning, in Spring 2022. Data are from a 2019-22 study of teaching and learning using match-funded 'mastery' resources, Power Maths. Visits to year 2, 4 and 6 classes gave access to children's views on their 'new normal'. We focus on responses to two Power Maths pedagogical devices, 'Reflect' and 'Challenge' and also their thoughts about mathematical explanations. In at least seven of nine schools, children usually responded positively, articulating the learning potential of wrestling with such tasks. In two schools where teachers had invested heavily in knowing the linked teacher-educative support materials, the children's quality of mathematical explanation, and of written response, was outstanding. While our data also show pandemic-related learning loss persists, we suggest that use of well-structured curriculum resources can still support high quality thinking that augurs well for children's mathematical development.

Keywords: primary mathematics; reflection; explanation; challenge

Background

Power Maths (first published by Pearson from 2017) is designed as a 'coherent set of mathematics materials' for use in R-year 6 (usually age 4-11) in England, where primary teachers of mathematics are typically non-specialist. Teacher resources are largely accessed electronically ('ActiveLearn'), though print 'Teacher Guides' are also available. Online resources for whole-class use are complemented by textbooks and practice books. Power Maths is designed to align with the 2014 National Curriculum for England, with aims of supporting fluency, problem-solving and reasoning – and mathematical communication, together with positive affect. Lesson plans claim to support a whole-class 'mastery' approach to learning via structures of whole class teaching and same-day interventions, and the series attracts school purchase subsidy by the English Department for Education. Other key approaches to mastery used are to support children's deeper conceptual grasp via **reflection** on learning, **explanations** for their mathematical thinking, and appropriate **challenge**. In 2018-22 the first author led a study exploring national curriculum enactment in classrooms using Power Maths, and the impact of those resources on teacher and children's learning. Serendipitously, we were also able to evidence impact of the pandemic on teaching and learning in study classes.

The literature offers some insights into the use and impact of curriculum materials within curriculum reform. For example, Schmidt and Prawat (2006) argue a deep-seated coherence of all aspects of the curriculum system (including teacher capacity and resources) is needed if aspirations are to be met. Remillard (2005), working with primary teachers in the USA, shows the curriculum experienced by pupils shows significant variation, depending on teacher knowledge, beliefs about mathematics, students and about how students learn, and other teacher orientations towards the materials used. Importantly for our study, Davis and Krajcik (2005) characterise *(teacher-)educative* materials to contain additional supports, communicating to teachers anticipated student thinking and misconceptions, key mathematical ideas, and the rationale behind particular design decisions, as well as the range of possible teacher and learner roles within that, and Gueudet, et al. (2012) evidence the use of those. Oates (2014) analyses that the highest quality materials are underpinned by well-grounded learning and subject-specific content theory; include coherent learning progressions within and across the subject; stimulate and support learner reflection; feature varied application of concepts and principles – 'expansive application'; and control surface and structural features of texts to ensure consistency with underpinning learning theory. Power Maths is designed to both be teacher-educative and to meet Oates' criteria. However, we note that there is still comparatively little evidence around the impact of textual materials on student mathematical functioning or affect, and (especially younger) children's voices in related literature are unusual: the data reported here contributes to filling that gap.

In this paper, we evidence children's views on mathematical explanation, reflection and challenge using Power Maths, because of their roles in promoting deeper mathematical learning. Kyriacou and Issitt (2008) show **explanation** is a key feature of effective teacher-pupil dialogue that promotes conceptual learning, including via exposure and addressing of errors and misconceptions (Ryan & Williams, 2007). Mathematical explanation in whole-class discussion is known to support student learning and active listening (Walshaw & Anthony, 2008), and self-explanation improves mathematical learning (Rittle-Johnson et al., 2017). We know that effective metacognitive strategies include demand for (oral and written) **reflection and challenge** (Ellis et al., 2014); those also support cognitive activation (Baumert et al., 2010); conversely, productive engagement with genuine challenge requires nurture of metacognition (Kramarski & Mevarech, 2003). Woodward et al. (2012) also point to the role of productive challenge in problem solving.

Power Maths adopts specific pedagogical devices to support these activities. For example, teacher materials promote whole-class introduction that probes prior learning with justifications, with children responding in whole sentences, **explaining their thinking**, and demonstrating on the board. Children are expected to **explain-to-peer** and use peer support during independent work. Written questions use '**explain boxes**', and series characters' competing approaches or errors. **'Reflect**' tasks intended for whole-class use support lesson-synoptic grasp, and **'Challenge**' near-end tasks dig deeper with target learning. Taken together, the literature suggests such devices support flexible (deep) fluency, reasoning and problem-solving.

Much of the source study took place over the pandemic, and findings need to be interpreted in light of that. National evidence around the impact of the pandemic on children's mathematics learning, usually using standardised tests, shows that primary children performed at a lower level in Autumn 2020 than pre-pandemic, with a further drop by Spring 2021 especially among younger children. By Summer 2021 there was some 'recovery'. Curriculum areas known to cause difficulty, e.g. fractions, showed the biggest impact (e.g. Twist et al., 2022). *However,* these assessments' focus on easily measurable estimates of large-scale 'learning loss' may be missing important aspects of learning harder to quantify and often less tractable to address, e.g. genuine problem solving, unstructured mathematical communication, and/or multi-step reasoning, and our more 'classroom-close' qualitative approach offers complementary evidence. Following our 2018-2021 focus on teachers' and children's use of Power Maths resources, and the impact of those on their mathematical learning, including, through the pandemic period, from Autumn 2021 we also asked:

- What are the residual effects of the pandemic on teaching and on children's learning?
- What is the emerging 'new normal' use and impact of Power Maths materials?

The study

The study was piloted in 2018-19, with the main study following up to 42 classes from 21 broadly representative schools through two years:1/2, 3/4 or 5/6 (typically ages 5-7, 7-9 or 9-11 respectively). All classroom researchers were subject specialists independent of Pearson, with careful attention given to ethical tensions arising from funding by the publisher. We had termly interactions with class teachers, and planned intensive March visits to schools each year (in abeyance in 2021), conducting full lesson observations with each class and following those with class children's focus groups. Further details, and earlier findings, are in e.g. Barrow et al., (2021). Nine (again, fairly representative) study schools agreed to continue into 2021-22 with classes in years 2, 4 and 6, allowing a focus on the post-pandemic emerging 'new normal'. Here, we draw in particular on our analysis of Spring 2022 focus group data (92 children in 18 mixed-prior attainment groups), though contextualised within a wider 'story' of teaching and learning through the pandemic.

Findings

When Power Maths was first published from 2017, many teachers struggled to make full use of structures for reflection, explanation, challenge (and interpretations of 'fluency' were often unambitious). Early pandemic, most study teachers prioritised literacy and mathematics 'basics', and many felt that Power Maths was 'too ambitious' for teachers and children unused to remote working; further, reliable formative assessment of children's learning was difficult. Conceptually demanding areas such as fraction work proved a significant challenge, and children reportedly lost confidence and resilience as well as fluency in basics and vocabulary. Younger children's learning was often hardest hit. However, some teachers said the pandemic catalysed Power Maths-supported professional learning around priorities and key ideas, and this was reflected in their lessons.

By Autumn 2021, many teachers reported making more active use of formative assessment than pre-pandemic, but often remained focused on a fairly superficial 'fluency' catch-up. By March 2022, though, our observations showed some gaps still evident, but most classrooms with renewed mathematical ambition (supported by enhanced teacher capacity), and a level of explanation, reflection, challenge often higher than pre-pandemic. In two schools where teachers had invested heavily in knowing the linked teacher-educative support materials, the children's quality of mathematical explanation, and of written response, was outstanding. Further, in at least seven of the nine continuing schools, children usually responded positively to enhanced expectations around explanation, reflection and challenge.

Children were able to reflect on why different approaches supported their learning. They recognised that 'getting stuck', and talking and writing about their mathematics, enhanced thinking, and enjoyed engaging with a range of approaches to questions. They were able to identify structure for, and achievement of, progression both over a single lesson, and over time, and recognised the roles of teacher and peer support, and of a variety of iconic and physical representations in their learning. In what follows, e.g. '(P3) (S05 y4FG)' indicates data sourced from pupil 3 in the school

5 year 4 focus group, with any interviewer's comments in brackets, and so far as is possible, we have selected 'typical' quotations.

Some children identified the wider role of **explanations** and choices, including for later adult life:

> I like that when you do the explaining, I know that there are quite a few jobs where you need to explain why you want that to happen. Like if you wanted to make a law, you would have to explain why (P3) (S05 y4FG);
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> I like how you can choose, sometimes you can choose, what method you want to do, and explain why. If someone says something like this, and then someone says something like that, you can choose the easier method to work out the answer (S13 y4FG) (Fantastic. And you do a lot of that, didn't you? I was really impressed today, because you had lots of different methods).

Power Maths uses named characters to promote mathematical curiosity, confidence, determination, and creativity, and most children were able to identify characters' roles in catalysing discussion and explanation, for example around competing approaches:

> (Do they help, I mean those people?) Oh yes, they ask questions. (And is that good? I'm seeing nods.) Sometimes they give you clues; They have like speech bubbles asking you what to do; You have to answer them and tell them if they're true or are they false and why (S19 y2FG);
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> I read the speech bubbles, what the people say. (I was going to ask you about that. So, why do you use the speech bubbles?) Because they give us clues and they give us ideas how to work out the answer…. (S05 y4FG).

Almost all children were also able to articulate the benefits for them of using whole-class talk for developing explanations:

> (I want to ask you about is the time that you spend as a class where you're looking at questions on the board and your teacher is helping you unpick them, and you might do some work….How do you find those bits of a lesson? P1). I think it is good for you, but we can have more of that because it helps other people understand different tactics of doing the maths question. Because some people might be struggling with their method, but your method could be a breakthrough and they can help you do it (S05 y6FG).

They frequently identified 'explanations', especially written explanations, as being a source of special challenge (and that verbalising a response was often easier), but recognised the role such questions could play in their learning. Others identified complex, sometimes multi-step, questions as being particularly difficult for them – but again, understood their intent:

> Personally I find it quite tricky to answer the "explain your answer" questions (P1). Yes. ….I think the explain questions are also hard as well because most of the time I know what I'm talking about, but it's just hard to write it down and put it on paper (P2). (Do you do a lot of explaining in maths then?) Yes. Basically every day (P3). (…do you think it's good that you have to explain in your lessons and in your books or would you rather you didn't have to?) I think it helps sometimes when you're really struggling with the question, and you've just got to see when you write it out you don't forget (P2). Because say if you do it in your heads, you've got a lot of steps to do, you forget some. But say if you write it out on paper, it's there. I think it helps you remember what it's really about next time (P4) (S12 y6FG).
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> Writing it down helps you think, even if you get stuck writing it down (S19 y2FG).

'Reflect' and **'Challenge'** are particular Power Maths pedagogical devices that routinely occur at, or near, the end of a unit respectively. Again, most children were able independently to articulate the role those played in their learning:

> The Reflect is useful because it tests if you've actually understood the lesson (P1)….It's basically, in other words, asking you to explain what you've learnt. But sometimes using diagrams, things like that. And it's not always very challenging, but it basically just makes you think about what you've learnt…. So, things like that, you might realise things you've learnt (P2) (S05 y6FG);
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> Always after the challenge there tends to be a Reflect. I think they're very useful, because once you've done your work, sometimes I feel like I need a bit more thinking about it so I don't just forget about it and then we do something else (P1). I think it's good in the Reflect, because you reflect on it, and it has a question and you get it stuck in your head. So I think the Reflect is very helpful in helping you understand (P2) (S05 y4FG);
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> The Reflect is the hardest one so that's why we do it together (P1); And sometimes the Challenge is really hard too (P2); Yes, because Challenges are meant to be very hard (P3) (S19 y2FG).

Many children reported enjoyment of wrestling with 'Challenge' tasks:

> I really like the Challenges. They're quite fun. They're like, although sometimes it's hard to explain things, I actually like quite a bit of a challenge (S05 y4FG);
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> It takes a lot of work to get there, but you feel a good sense of accomplishment once you've finished it. (Do you like those kinds of questions where you really have to use what you already know and think quite hard? I've got a lot of thumbs up and nods there) (S05 y6FG);
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> (What about if you actually get a Challenge question right? How does that make you feel?) It just makes me feel good inside (P1). That makes me feel proud of myself that I could actually do it (P2) (S19 y4FG).

They specifically reflected on getting stuck:

> I find the Challenge difficult, but I find it better to be difficult than to be easy (P1). (You like a bit of a challenge?) Yes. (Do you think it makes you learn better?) Yes. (P2's nodding as well). If you never get a question wrong, how are you really going to learn? (P2) (Good point. It's only when we're really struggling with something we're learning as well. P3?) I normally get to the Challenges, but I only do half of them because the other half are a bit tricky, so I'll either ask the teacher for help or I'll ask my learning partner because she normally gets on with it too (P3). (Excellent, so you've got things there to help you if you do get stuck with those?) Yes (S13 y6FG).

Discussion and conclusion

Our study data is consistent with much of the published large-scale pandemic-related evidence, including around persistent pandemic-related learning loss, but is more subject-specifically nuanced. It shows that in some English primary classrooms supported by high quality teacher-educative resources, approaches to mathematics teaching and formative assessment have sometimes expanded from pre-pandemic.

The study also demonstrates the depth and fluency of some primary children's analysis of their mathematics learning, and their embrace of mathematical thinking and challenge when those are complemented by approaches which support positive affect. It evidences their valuing of mathematical explanation, reflection and challenge in such contexts. Importantly, the study suggests that invested use of high quality teacher-educative resources can support the development of mathematics classrooms in which teachers and children are confident to embrace and master depth and robustness of a wide range of mathematical thinking, despite recent challenges. Further work is needed to establish what might limit the scaleability of such development.

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