Going deeper: Exploring ways to achieve 'mastery at greater depth' in the primary mathematics classroom

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Although state schools in England are being encouraged to ensure that their pupils, where appropriate, achieve 'mastery at greater depth', limited school budgets restrict their opportunities for purchasing suitable mathematical resources. In a project funded by the Faculty of Education at the University of Cambridge, the university's mathematics outreach team NRICH worked with a group of primary schools in Tower Hamlets to explore ways to deliver existing, freely-available problem-solving resources to fulfil the requirement for teaching and learning 'mastery at greater depth'. The planned project involved a year-long series of professional development events for teachers, gap tasks and a case study with four of the participating schools. Despite the project being delayed by school closures during the Covid-19 pandemic, this paper explores its initial findings which indicate ways that schools might consider adapting their use of existing problem-solving resources to enable their students to achieve 'mastery at greater depth'.

Keywords: mastery at greater depth; primary; resources; whole-class teaching; problem-solving.

Introduction

Following the implementation of curriculum reforms (DfE, 2013), English schools have been increasingly encouraged to adopt the following 'mastery' approach towards the teaching and learning of mathematics:

> Pupils are taught through whole-class interactive teaching, where the focus is on all pupils working together on the same lesson content at the same time, as happens in Shanghai and several other regions that teach maths successfully. This ensures that all can master concepts before moving to the next part of the curriculum sequence, allowing no pupil to be left behind. (NCETM, 2016, p.1)

This approach, focusing on whole-class teaching, contrasted sharply with the previous government's focus on differentiation and group teaching. The policy change favouring whole-class teaching, initially among primary schools but more recently in secondary schools too, raised concerns among some educators regarding the level of challenge faced by some students in their mathematics lessons. Government-funded guidance for schools acknowledged those concerns, "It is inevitable that some pupils will grasp concepts more rapidly than others and will need to be stimulated and challenged to ensure continued progression," (Askew et al., 2015, p. 2). The guidance adopted the phrase 'mastery at greater depth' and suggested the following characteristics of pupils working at that level:

> • solve problems of greater complexity (i.e. where the approach is not immediately obvious), demonstrating creativity and imagination;

> • independently explore and investigate mathematical contexts and structures, communicate results clearly and systematically explain and generalise the mathematics.

Anecdotal evidence indicated that many primary teachers were struggling to satisfy those expectations in their classrooms using their existing teaching and learning resources, and that their school budgets restricted their opportunities to purchase new teaching materials. Hence this small-scale research project was intended to explore ways to deliver existing, freely-available problem-solving classroom resources to address mastery at greater depth in the primary classroom by investigating the following research question: *How could teachers deliver NRICH resources to support deep mathematical understanding in the primary classroom?*

The project was led by NRICH, the outreach mathematics project based in the Faculty of Mathematics at the University of Cambridge. NRICH specialises in designing 'low threshold, high ceiling' (LTHC) mathematical problem-solving activities intended to be accessible to most, if not all students, yet posing a level of challenge as pupils work their way through the activities. This research-informed LTHC approach was pioneered by Papert (1980) in his work on computer programming and it has since been adopted by NRICH.

Method

This research project formed part of a wider NRICH-led project involving teachers from twenty primary schools in Tower Hamlets who were participating in the year-long professional development programme 'Going deeper to develop whole class reasoning'. The overall project was intended to involve a series of face-to-face training days exploring a selection of LTHC activities.

The project adopted a multiple case study approach where each of the participating schools would be regarded as a single case (Stake, 1995). A convenience sample of four schools volunteered to host a researcher for two visits to their classes during the academic year. Adopting the principles of ethical research outlined by both the Faculty and BERA (2018), all names and institutions have been anonymised.

To address the research question, the data collection for each school was intended to include lesson observations, work and planning scrutinies and interviews with both teachers and focus groups of pupils. During each lesson observation the teachers were encouraged to deliver an NRICH LTHC activity which had been introduced to them during a previous training day; the teachers were asked to plan their lesson to allow for pupils to work at greater depth, where appropriate. The teachers would also be asked to share their pre-lesson planning decisions intended to support deepening understanding in the lesson and reflect on their impact after the lesson. The interviews and focus group discussions would be recorded on hand-held recorders and professionally transcribed. The analysis would address the three key features of working at greater depth proposed by the NCETM (Askew et al., 2015); namely solving unfamiliar problems, working independently and communicating results.

To allow the teachers sufficient time to familiarise themselves with a selection of primary-aged LTHC resources and the concept of teaching mastery at greater depth, the first round of visits was planned for the second term and a second visit in the following term. Two of the initial round of school visits were successfully completed before the Covid-19 pandemic forced the closure of the participating schools. This research paper reports on the findings from those two schools.

Findings

The findings revealed that the teachers adopted a range of strategies to address the three key aspects of mastery at greater depth using existing teaching materials.

Solving unfamiliar problems

The importance of setting aside time to fully explore the existing problem-solving activities before introducing them to their classes was noted during the interviews:

> I mean, I consider myself greater depth, okay? And if I find it a challenge and I'm greater depth then clearly there are no children that know more than I do. I don't think there are. I do have, you know, quite a high level of maths. So, basically, if I have a greater depth and I'm enjoying it and taking it on and forward progressing, clearly those children can do the same, can't they? (Teacher A)

Using this approach, the teachers identified activities such as Amy's Dominoes (nrich.maths.org/1044) and Tea Cups (nrich.maths.org/32) (Figure 1) as suitable problem-solving activities for teaching at greater depth.

Figure 1: Two of the existing NRICH problem-solving activities identified by the teachers as suitable for teaching at greater depth.

Classroom behaviour was one of the key factors identified by teachers for reflecting on the suitability of a resource for teaching at greater depth:

> I feel it when I look around the class. If it's quiet and everyone is talking or, you know, some people are working and some people might just be looking or something, I feel it and then when I start to see children looking out the window now that's when I know that some people have either like lost their way, or, you know, a bit of an intervention or something like that. So, it's just the general behaviour of the class. That tells me that they're involved. I also go round and see what they're doing. But I love it! (Teacher B)

The importance of involving all pupils at the beginning of the lesson reflected the mastery approach the schools were following as well as the LTHC design approach behind the resources. However, the findings indicated several additional strategies for teaching at greater depth. The teachers reported that they needed to consider the problem-solving lesson within a longer teaching sequence, rather than as a standalone activity. Also, they sometimes needed to allow sufficient teaching time to enable their pupils to become familiar with required resources before the lesson to avoid overloading them during the session itself; for Amy's Dominoes, this approach involved setting aside time the previous day to explore domino sets in pairs:

> So, we played dominoes with them. And also, it was the first day back so I didn't want to do anyone in. I wanted everyone to have a nice day so we played

> dominoes. And it was surprising because the majority of the class couldn't play dominoes. Basic classic dominoes. They couldn't play it. You know, they didn't know there were two ends. They were just making all sorts of patterns. (Teacher A)

Working independently

Although each of the teachers decided to present their chosen problem-solving activities unchanged to their classes from how they appeared on the NRICH website, they allowed time to carefully read through the problems with their classes and asked them to put the challenge into their own words to demonstrate their understanding before encouraging them to attempt the problems for themselves. The teachers also decided that their pupils should work in pairs rather than larger groups, which they felt was the optimum approach for developing a degree of independence alongside offering a suitable level of peer support.

Another strategy for supporting independent working adopted by the teachers was choosing activities originally intended for younger pupils. Their main intention was to reduce the cognitive load required during the session:

> Try to get something a bit younger. And as I've said to you, I've realised over time that the easier the problem the better. Because one, you can develop it yourself, you know. And two, everyone gets involved at the beginning. And I just try it. (Teacher C)

During the observed lessons, the teachers balanced independent working with mini-plenaries to share ideas, large easels at the front of the classroom to both record ongoing findings and emerging key questions from their classes as well as keeping the actual problem under investigation on display throughout the lesson.

Communicating ideas

The ability to clearly communicate ideas is one of the key aspects of working at greater depth (Askew et al.,2015). In each of the observed classes, pupils were encouraged to share their ideas throughout their lessons. In one class in School2 , each pair was encouraged to lay out their answer to the Tea Cups activity on the floor so that the others could explore their solutions and write up their findings (Figure 2).

Figure 2: Pupils were encouraged to share their ideas with their classes by placing their work on the floor.

To support their pupils share their ideas and findings with others, the teachers provided pupils with sentence starters provided by the team at their local Professional

Development Centre. Pupils were encouraged to use sentence stems such as 'I think the question means…' and 'I know that... therefore I would try…' In each school suitable sentence stems were clearly displayed on class walls and the teachers frequently referred to them in the lessons (Figure 3).

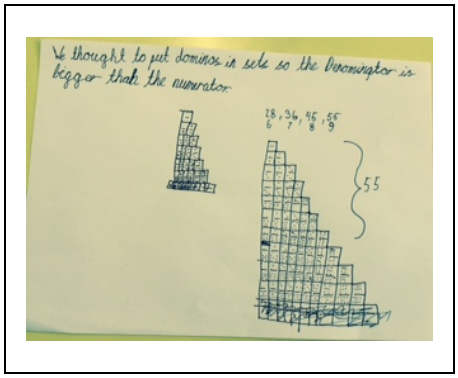

Figure 3: A cross-curricular approach using sentence stems supported pupils to share their thinking with others.

Some of the teachers celebrated the problem-solving work by producing class scrap books. After completing each investigation, additional class time was allocated to writing up their solutions in readiness for inclusion in the scrap book. Moreover, one of the teachers reported the usefulness of the existing student solutions published by NRICH to further develop communication skills within their own classes, allowing additional class time to explore those contributions and reflect on them:

> I really like the solution thing now that I know how to use it and things. Getting the language out of it and stuff and using it after they've done it. Maybe tomorrow before we do that, we might start by looking at the solution that was there which I couldn't understand this morning. But clearly, I'll understand that tomorrow. Everyone will understand it tomorrow and then we can really, you know, look at it and decide whether we like it and pull it apart. (Teacher B)

One of the unexpected findings from this research was the opportunity for pupils to reveal their mathematical skills when planning for working at greater depth:

> What's great about NRICH activities is that it just shows children can shine even if we've got them in a box under-expected. That's what I love about it. Because, you know, that boy, Tom, who kept calling out the answer, just because he suddenly worked it out and he didn't even know why. And he couldn't even put in a sentence. That boy is brilliant at maths. But until he has come into year five, you know, he is underachieving, doing terrible in the test, doesn't understand anything, badly behaved. You know, he completely steps out of the box and he's shining. And he's very artistic, that boy, so there is probably a link there. (Teacher A)

Conclusions

These findings indicated that schools can deliver the three key aspects of mastery at greater depth using existing, freely-available problem-solving materials. To do so, teachers need time to try the chosen problem-solving activities for themselves before their lessons and the flexibility to adjust their weekly plans to accommodate unforeseen additional tasks, such as introducing their classes to the game of dominoes. The teachers encouraged independent working by using paired work alongside mini-plenaries and the use of class displays. They also considered tasks aimed at younger pupils to reduce the cognitive load, which was an interesting finding considering the focus on greater complexity by the NCETM (Askew et al., 2015). The

suitability of the chosen task was further reinforced by reflecting on the behaviour of the pupils during the session. The teachers supported their pupils to communicate their findings using sentence stems and celebrated their work using class scrap books. Perhaps the most positive finding was the suggestion for teachers to be prepared to be pleasantly surprised!

Acknowledgement

NRICH would like to thank the teachers and colleagues from the Tower Hamlets Professional Development Centre without whose support this project could not have been possible.

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