Maths Hub, mastery and messy research

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Maths Hubs, funded by government and coordinated by the National Centre for Excellence in Teaching Mathematics (NCETM), were set up in England 2014 to act as regional focal points for the development of excellent practice in mathematics teaching and learning (www.mathshubs.org.uk). Hubs support local 'work groups': activities initiated by practitioners. This paper reports on work undertaken by a team at one university working with one of the North West Maths Hubs. Two primary teachers working in university partnership schools undertook short classroom based research projects around themes of teaching for conceptual understanding, and use of concrete apparatus. The teachers were supported by two university ITE tutors with interests in teaching for 'mastery' and in teachers' professional development. The teachers reported developments in their own thinking and practice. Also, the community of practice within the university primary mathematics partnership has been enriched though a focus on active practitioner research.

Keywords: mastery; conceptual understanding; practitioner research

A 'mastery' curriculum

The current National Curriculum has been designed to reflect the curricula of other high performing education systems. It is a curriculum that encourages depth and breadth of mastering content as opposed to accelerating through yearly learning objectives (Askew et al. 2015 p.4). There is an expectation that the overall aims of the National Curriculum for mathematics should be embedded into primary school teachers' practice to ensure high expectations of pupils' learning and mastery of the subject. So for the purpose of this study it is important that the term 'mastery' is explored. Mastery in theory may be easier to define than mastery in practice, and it is hoped that this research will offer teachers more clarity with regards to what Townsend (2015) describes as a 'nebulous concept'.

According to Askew et al. (2015), the term mastery has been used in four different ways: a mastery approach, a mastery curriculum, teaching for mastery, and achieving mastery of particular topics and areas of mathematics. A mastery approach is described as a set of principles and beliefs (p.5). This can be equated to having high expectations of what a child can understand and enabling a child to have a growth mindset rather than a fixed mindset (Dweck, 2006); so in fact there is a relationship built between both teacher and pupil based on positive attributes to learning. The teacher will also need to have a growth mindset to, if necessary, alter their previous attitudes and beliefs regarding children's capabilities and then revisit how they teach. Drury (2014 p.12) reiterates this and states that 'Dweck's research demonstrates that pupils and teachers who believe that intelligence is flexible, and that their goal is to learn as much as they can, are more successful than those who focus on passing exams and completing tasks'.

A mastery curriculum builds on the idea that all children can do mathematics, provided that the curriculum content addresses teaching concepts securely and makes connections between different mathematical ideas (Askew, M., Brown, M., Rhodes, V., Wiliam, D., & Johnson, D 1997). In this study, teaching for mastery is the aspect of mastery which is most prominent, as the teachers involved were keen to address their pedagogical approaches in light of the mastery curriculum.

Finally, achieving mastery of particular topics and areas of mathematics links to Skemp's (1976) definition of relational understanding and instrumental understanding. He states (p.21) that relational understanding is, 'knowing both what to do and why.' He continues to explain that 'instrumental understanding is 'rules without reasons'', in other words learning procedures without conceptual understanding. This aspect of mastery clearly promotes relational understanding, and therefore being able to apply mathematical knowledge and skills to different situations. All four aspects of mastery clearly relate to a teacher having a deep understanding of the teaching and learning of mathematics.

Is mastery new?

> There's nothing new about the desire among teachers to help children develop deep understanding of the subject. But the widespread use of the word 'mastery' in relation to maths teaching and maths learning is relatively new, and we think it is a useful label that encapsulates this key aim. NCETM (2015)

From our explorations of the term mastery, it is evident that effective mathematics teaching has always promoted a mastery approach. The Cockcroft report (1982: para 243) set out a list of what was considered to be best practice in mathematics and made it clear that this was a repetition of what had already been stated before in official reports. The list was: 'exposition by the teacher; discussion between teacher and pupils and between pupils themselves; appropriate practical work; consolidation and practice of fundamental skills and routines; problem solving, including the application of mathematics to everyday situations and investigational work.'

Since the Cockcroft report, the same key messages have been repeated in research and reviews of primary mathematics education. In 2008, Williams called for there to be "at least one mathematics specialist in each primary school, in post within 10 years, with deep mathematical subject and pedagogical knowledge" (p 7). Thus mathematics specialist teacher (MaST) courses emerged, supported for a short time by government funding. Findings from Ofsted (2008) contributed to Williams (2008), and subject expertise was directly referred to, with a list of its key characteristics. This list could be a list to define mastery and it fits perfectly with the purpose and aims of National Curriculum 2014. For example, 'understanding the conceptual difficulties of different topics' and 'knowing what questions to ask to probe understanding and to identify and tackle pupils' misconceptions' (Ofsted 2008: p.39). It could be suggested that the 'mastery curriculum' is designed for a mathematics teacher with a Profound Understanding of Fundamental Mathematics (PUFM), (Ma, 1999). If this is the case, it poses the question, 'What further challenges will schools, Maths Hubs and teacher education providers face in order to suitably equip primary pre-service and serving teachers for a mastery mathematics curriculum?'

Use of concrete apparatus

The school in which this research project took place is a two form entry primary school in an affluent area in Liverpool. The school's results show that it is an above average performing school. Yet school data available from RAISEonline (2015) highlight that there are gaps in progress in mathematics for some children with special educational needs within the school.

The researcher worked with four children who had been identified as underachieving in mathematics. The children were aged between 6 and 7 years of age. The aim was to observe whether working with concrete apparatus and having focused sessions supported the children's learning and knowledge of mathematical concepts and helped to develop understanding. The demands of the new curriculum now require that most children progress through the curriculum content at the same pace. Williams (2008) recommended early intervention for primary children struggling with mathematics and that children with severe difficulties should receive intense one-to-one support from a qualified teacher. Therefore it is vital to find ways to ensure that underachieving children are able to access the same lesson content as their peers through differentiation and the use of concrete apparatus, linking to the ideas of Bruner (1977).

The researcher first observed and recorded the children's basic abilities in number. She asked the children to perform simple tasks such as recording number bonds to 10 and 20. She then asked them to complete various number sentences involving the four operations. The children were asked to do this using their mental skills only. The scores for independent work without apparatus were low, but of more concern was the children's low motivation to try and complete a task. The children were using task avoidance techniques such as asking to go to the toilet or trying to engage their peers in conversation. This led the researcher to reflect that it is important to find ways of ensuring that a child feels that they have a chance of success by tailoring their specific needs through differentiation and apparatus available in the classroom. Concrete and pictorial representations needed to be carefully selected to help build procedural and conceptual knowledge together.

After this initial observation, during the next sessions with the children the researcher introduced concrete apparatus such as Numicon, counters and number lines to help the children solve answers to questions that earlier they had been unable to answer. Immediately the children seemed more motivated and were pointing to the correct Numicon pieces when asked to build a number. Their conversation had more mathematical content and they were able to talk through solutions by building number sentences up slowly to show a concrete and pictorial representation of the number sentence. They had grown in confidence and were a lot more focused than observed previously. They were able to manipulate the apparatus and work independently through a question with confidence.

This led the researcher to reflect on the importance of the use of concrete apparatus for children who find Mathematics difficult, especially in the early stages of developing their mathematical knowledge. It helps children build confidence and gives them the ability to work more independently. Skemp (1976) emphasised the importance of a child building a relational understanding of their knowledge in order for them to build their 'schemas'. He stated that "The more complete a pupil's schema, the greater his feeling of confidence in his own ability to find new ways of 'getting there' without outside help" (p.25). The child needs to access many different forms of apparatus and have these available during all lessons. Another consideration in enabling children to achieve is to have as much parental support as possible. Building a relationship between the teacher and parent can also be an important factor to help a child succeed. The Department for Children, Schools and Families (DCSF 2008, p.2) stated that, “Parental involvement in a child’s education from an early age has a significant effect on educational achievement.” Having parental support during this project helped children to consolidate their learning further at home and gave the parents an opportunity to observe how their child solved number problems.

As with any research project there were external factors that may have impacted on the results. The research took place at the end of the summer term which meant that the children were very tired, and excited about finishing for their summer holidays. This could have affected their concentration levels. Allocating time to work with the children also proved difficult. Many sessions were held during different parts of the school day because the researcher’s duties as a teacher meant that she was unable to leave the class for long periods of time. If pursuing further classroom-based research, careful consideration would need to be given to time allocation. However, being involved in this research project has helped to develop the teacher-researcher’s own thinking and practice, and led her to read further into ways of supporting children, especially in the early years of their mathematical learning. She will use the results from this project to help her work alongside and support new teachers, and to work with children to develop their confidence and success in mathematical thinking.

Teaching for conceptual understanding

The need to understand the relationships between different aspects of mathematics is central to current thinking, including that which lies behind the rationale of the 2014 National Curriculum, and its intent to slow learning down in order to secure and deepen it. In itself, this national directive reveals that almost 40 years on, teaching hasn’t yet caught up with Skemp’s (1976) philosophy: there still appears to be an inherent mindset within the teaching profession that a teacher’s job is to tell students what to do, rather than get them to understand what they are doing and why it works. This part of the study set out to address such a mindset by looking at the difference between teaching for conceptual understanding and teaching as a means of getting an answer. To do this we chose the topic of ‘area’, believing it to be a difficult concept for pupils to grasp - one that produced many misconceptions and uncertainties, as well as opportunities for making links and formulating relationships across other areas of mathematics.

The school where this research was carried out is in Toxteth, Liverpool, in an area of high deprivation. 94% of the area is within the most deprived 10% nationally. Child poverty affects 53% of children (compared with 19% nationally and 33% in Liverpool). The school has a very high level of pupil mobility, which impacts on class dynamics and stability. There are high levels of Pupil Premium children and pupils with EAL (82% and 80% respectively), with great diversity within the EAL population itself (30 countries represented and 25 home languages spoken including English). The number of children with special educational needs is also high.

Introducing the concept of area

The wording of the curriculum shows an attempt to curtail the formulaic ‘area = length x width’ approach by making the ‘counting (of) squares’ explicit, hereby advancing the concept of internal space being measured in a specific way. Although this was taken into account and a relevant definition given (the amount of space that a

2D shape covers), the control group (‘Group A’) was taught instrumentally, while the project group ‘Group B’ undertook activities that sought to develop conceptual understanding.

Teaching activities for group A included: counting squares within rectangles drawn on a grid; linking the counting of squares to the formula A = L x W; using formula to calculate area when length/width have different units; measuring classroom objects, using the formula to calculate the area; counting squares on rectangles that have images over part of the inner grid, and within rectilinear shapes; cutting out rectangles from grid paper and join them to form rectilinear shapes, using these to find a total area.

Teaching activities for Group B included: contrasting the measurement of lines and rectangles in order to discuss the meaning of ‘area’; covering rectangles with tessellated shapes, contrasting the ‘merits’ of different shapes and discussing the concept of regular, standard units; ordering rectangles (smallest to largest area); making different rectangles/rectilinear shapes from square tiles; using chalk to split an area of the schoolyard into square metres, drawing a representations on dot paper; using grid paper to make arrays that represent grid method for multiplication.

All the pupils who took part completed a post-teaching questionnaire that assessed the pupils’ understanding of the topic. The pupils’ answers were rated into one of three categories: relevant, partially relevant, not relevant, with ‘Group B’ showing a significantly higher level of relevance, and therefore understanding, on all questions. The answers to the questions also revealed a much greater development of language in respect to the topic, as well as a greater depth of understanding. Three children from each group, each representing a different attainment level (high, middle, low), were also chosen to complete a summative test with 12 possible marks. To remove issues pertaining to the understanding of language, all questions were read by the teacher. The results were as follows:

	high	middle	low
Group A	0% (0/12)	42% (4/12)	50% (6/12)
Group B	75% (9/12)	67% (8/12)	58% (7/12)

The results reveal the strength of Skemp’s relational model and the need for teachers to plan activities that build conceptual understanding, instead of seeking to condense learning into simplistic formulae or sets of rules. Such learning will be applied more fruitfully, build over time and have greater longevity. However, this poses interesting questions for schools like the one where this study took place. It is a process of learning which supports language development, this being beneficial to pupils with EAL. Despite this, high mobility within the school means that pupils arrive at varying points in their educational journey. Also, gaps can develop in pupils’ learning due to issues relating to social deprivation. These issues gain significance because under the current system schools are judged on their external SATS results. A school has to ensure that it paints a healthy picture of itself. This being the case, teachers may feel forced to teach in whichever way is best suited for getting results: a ‘quick fix’ may well over-ride a slow approach to deep learning.

Implications for teacher development

We have seen that practitioner research can be complex and messy, but is a very powerful means of developing teachers’ understanding and practice. We return to our question about the challenges for schools, Maths Hubs and teacher education providers, in equipping teachers for a mastery curriculum. In order to develop the profound knowledge of fundamental mathematics (Ma, 1999) required in order to teach for mastery, teachers need to 'take time to talk about mathematics' (Campton and Stevenson, 2014, p.19). They need to develop a 'mathematical sensibility' (Askew, 2008, p.22) to enable them to respond to a changing curriculum, and to be open throughout their career to re-conceptualising their existing mathematical ideas as well as learning new mathematics. Above all they need confidence, enthusiasm, and a growth mindset view of themselves as learners in order to achieve this.

References

Askew, M., Brown, M., Rhodes, V., Wiliam, D., & Johnson, D. (1997). *Effective Teachers of Numeracy*. London: King's College, University of London.

Askew, M. (2008). 'Mathematical Discipline Knowledge Requirements for prospective primary teachers'. In P. Sullivan and T. Wood (Eds.), *The International Handbook of Mathematics Teacher Education Volume 1:* Rotterdam: Sense publishers.

Askew, A., Bishop, S., Christie, C., Eaton, S., Griffin, P., & Morgan, D. (2015). *Teaching for Mastery: Questions, tasks and activities to support assessment.* Open University Press.

Bruner, J. (1977). *The Process of Education.* Harvard University Press.

Campton, I. and Stevenson, M. (2014). 'Partnering theory and practice in mathematics teaching'. In Hyde, R. & Edwards, J. *Mentoring Mathematics Teachers.*

Cockcroft, W. (1982). *Mathematics Counts: Report of the Committee of Inquiry into the Teaching of Mathematics in Schools*. London: HMSO.

DCSF (2008) *The Impact of Parental Involvement on Children's Education*. Available at http://webarchive.nationalarchives.gov.uk/20130401151715/

Drury, H. (2014). Mastering Mathematics: Teaching to transform achievement Oxford: Oxford University Press.

Dweck, C. S. (2006). *Mindset: the new psychology of success*, Ballantine Books.

Ma, L. (1999). *Knowing and Teaching Elementary Mathematics.* Mahwah, NJ: Lawrence Erlbaum.

NCETM (2015). Mastery. Retrieved from https://www.ncetm.org.uk/resources/47230.

Ofsted (2008). *Mathematics: understanding the score*. Retrieved from www.ofsted.gov.uk/resources/070063.

RAISEonline (2015). Retrieved from https://www.raiseonline.org/login.aspx?ReturnUrl=%2f

Skemp, R. (1976). 'Relational Understanding and Instrumental Understanding'. *Mathematics Teaching, 77:20-26.*

Townsend, V. (2015) 'Observing Teaching'. *Proceedings of the British Society for Research into Learning Mathematics,* 35(2), 94-99.

Williams, P. (2008). *Independent review of mathematics teaching in early years settings and primary schools*. London: Dept. for Children, Schools and Families.