Developing a Mastery Approach to Maths:
Lesson structure, classroom strategies and teacher beliefs

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Two open access research journal papers underpin this CPD resource:

Boyd, P. & Ash, A. (2018) Mastery Mathematics: Changing teacher beliefs around in-class grouping and mindset. *Teaching and Teacher Education, 75:* 214-223. Available at: https://www.sciencedirect.com/science/article/pii/S0742051X1731274X

Boyd, P. & Ash, A. (2018) Teachers framing exploratory learning within a text-book based Singapore Maths mastery approach. *Teacher Educator Advancement Network Journal* 10(1): 62-73. Available at: https://ojs.cumbria.ac.uk/index.php/TEAN/article/view/442

To cite this CPD resource:

Pete Boyd, Andy Ash, Lucy Evans, Ann Kirk, Rosie Ross, Paula Spenceley, Vicky Stout, Adam Vasco and Keri Williams (2017) *Developing a Mastery Approach to Maths: Lesson structure, classroom strategies and teacher beliefs – An Open Access Professional Development Resource for Teachers*. Deep Learning Teaching Schools Alliance & LED Research Centre, University of Cumbria. Available at: http://insight.cumbria.ac.uk/id/eprint/3286/

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Introduction

By introducing and reflecting on two lessons in a Primary school, this resource aims to provide some insight into mastery approaches to maths. If good levels of trust can be established, then expert teachers experience powerful professional learning through the collaborative analysis of classroom video. This resource is informed by our collaborative practitioner research project in which we investigated change in teacher strategies and beliefs during their implementation of a mastery maths scheme, Maths – No Problem! (Boyd & Ash, 2018)

The Maths – No Problem! Scheme includes teacher guidance and pupil work books as well as the actual textbooks. It is not our purpose to particularly endorse or market the Maths – No Problem! Scheme, but it would not have been practicable to develop our research papers or this professional development resource without naming the scheme. The scheme is influenced by a South Asian, specifically Singapore maths, approach but has been further developed by the Deep Learning Teaching Schools Alliance in an implementation project now involving more than 90 Primary schools.

The professional development resource consists of four sections that we present, to reflect our inquiry-based philosophy, as questions:

1. How might a mastery approach lesson require change in teacher strategies?
2. How might a mastery approach require change in teacher beliefs?
3. What does research evidence tell us about the impact of mastery maths?
4. How might a school or alliance go about developing mastery approaches?

Sections 1 and 2 are based around two classroom video lessons* taught by teacher researchers and reflect the focus of our two forthcoming open access research journal papers. We have chosen to focus on 'strategies' in Section 1 and 'beliefs' in Section 2 because we believe that the teachers made significant changes in their classrooms by implementing the maths scheme and then, during the next year or two, came to change some of their embedded beliefs about what maths is and how best to teach it. Section 3 provides a brief overview of the development of 'research-informed practice', focusing in particular on mastery approaches to maths. Section 4 considers how you might manage a curriculum change project requiring professional learning for teachers, such as implementing a mastery approach to maths. We found that moving to a mastery approach in maths is challenging for teachers, children, schools and parents because it involves more than simply considerable change in lesson structure and strategies. It also involves changes in beliefs about what the subject of maths is and how all of us are able to develop high levels of skills and understanding and even come to feel, to different degrees, that we are mathematicians.

*We are grateful to the teachers, children and schools for their participation in creating the video clips and to Maths – No Problem! for the funding of the filming and editing.

SECTION 1: How might a mastery approach lesson require change in teacher strategies?

This initial section focuses on a concrete video example lesson to show what a mastery approach might look like within a maths classroom. Mastery approaches at classroom level will vary considerably depending on the teacher's knowledge and expertise, the children, the school context and if a particular maths scheme is in use. The video of Rosie's maths lesson, based on the Maths – No Problem! Scheme, demonstrates one mastery approach to maths.

Before watching the first video lesson, especially if you are new to mastery approaches, it is worth checking the principles of mastery approaches by considering the excellent and concise hand-out provided by the National Centre for Excellence in the Teaching of Mathematics (NCETM, 2016). It will also be helpful to consider the basic lesson outline below that originates from Maths-No Problem! lead author Dr. Yeap Ban Har and has been developed by the Deep Learning Alliance. As follow-up reading to engagement with the video lesson, you will find our open access research paper useful (Boyd & Ash, 2018).

Table 1. The lesson outline used by teachers in the project.

Lesson phase		**Outline**
Anchor Task	Exploring	One problem or stimulus is presented to pupils (based on what is in the textbook) and they are encouraged to explore it. The teacher uses this time to observe their responses and prompt further exploration with questioning to ensure that all pupils are challenged.
	Structuring	The teacher gathers together pupil's ideas for solutions and the class discuss them as a whole group, often re-exploring new suggestions.
	Journaling	Pupils record what they have been doing in their maths journals – there is an emphasis on showing things in different ways and effective communication of thinking.
Reflect and refine		The textbook is used and the teacher guides the class through the textbook solutions to the problem they have been discussing. There is a greater emphasis on teacher explanation during this phase.
Practice		The teacher starts off by guiding the class through examples of similar problems to the one they have just done. Then, pupils work through more examples independently with the teacher supporting them if necessary. All questions are typified by their mathematical variation – they are designed to extend pupil's thinking rather than just be lots of examples presented in the same kind of way.

The first video, of Rosie's lesson, is 26 minutes and is available at https://vimeo.com/229579050/385dda5052

During the video of Rosie's lesson, you might consider the following questions:

- How is this broad lesson structure and the teacher strategies being used similar or different to my approach?
- How does the lesson reflect the key characteristics of mastery approaches as summarised by the NCETM?
- What is the role and significance of the textbook scheme?
- To what extent do you feel there is effective learning in this classroom?

Rosie seems to have a firm idea in her head about the main focus of her lesson, that is the conversion of kilometres to metres. However, we see, at the start of the lesson, that she does not draw attention to this directly. Instead she invites the children to look at the textbook image and wonder about what the two children have been doing. By starting in this way, the lesson seems to begin with a 'low floor' activity – using open-ended discussion to make the lesson accessible to all pupils regardless of prior attainment. The varied responses from pupils at this point allow her to gather some quick assessment information and gain a broad overview of what sort of knowledge and understanding the children already have. You may also notice that she offers little or no judgement of the pupils' initial ideas, instead she offers comments such as "I wonder…" or "that's an interesting idea…" The intention behind this teacher stance is to promote thinking in the classroom, prevent pupils from becoming passive learners and create a supportive classroom learning environment that celebrates struggle and mistakes as learning opportunities.

Close to the start of the lesson Rosie mentions her friend, who thought that the two children might have been doing the high jump. This promotes thinking about what a kilometre actually is – do the pupils realise that jumping one kilometre high is impossible, or do they see it as a meaningless number? We see that, later on in the video, she uses this to reinforce the fact that one kilometre is equivalent to 1000 metres and therefore impossible to jump! We describe this as 'framing' learning because the class teacher is deliberately leading the children into thinking and talking about the intended concept that forms the purpose of the lesson.

Rosie leads the children to using some equipment to represent one of the distances (1km 20m). This is another example of framing – the choice of place value counters is deliberate as it is likely to promote deeper discussion about what one kilometre is (do you represent it with a 1 disc or a 1000 disc? If you choose the 1 disc, how do you represent the 20m? etc.). She does not leave use of the equipment up to chance; she deliberately asks them all to have a go at representing the distance. As the children work collaboratively, Rosie observes and gathers valuable assessment information. She chooses which of the pupils' ideas will benefit the whole class and she then asks one table to share what they were doing. Again she is framing the learning. Rosie uses an important strategy to promote high quality dialogue in the classroom. Instead of a two-way 'ping-pong' style interaction between teacher and pupil, she invites the whole class in their pairs, to consider one pupil's idea. In doing this, pupils are invited to think critically about each other's ideas, which creates an opportunity for formative feedback from peers and promotes metacognitive thinking.

A significant amount of lesson time is spent exploring the initial problem. The emphasis seems to be less on solving the problem (at this point it might be worth asking yourself what the problem actually is!) but on exploring *around* the problem. From a 'low floor' starting point, the pupils end up in this 'high ceiling' task, developing deep conceptual learning through talking about fractions and decimals in relation to conversion between metres and kilometres. It is important to acknowledge the concerns of some teachers and parents around a mastery approach, that pupils with high prior attainment in maths might not be stretched and should move on more quickly. Mastery approaches claim that these pupils are able to understand key concepts in depth, creating a firm foundation and positive engagement with the subject discipline of maths, rather than moving on quickly demonstrating apparent understanding by using speed and calculation to succeed in tests.

The design of the textbook plays a significant role here. In previous chapters the pupils have learnt about decimals and fractions and the relationship between them and in this lesson, through Rosie's planning and framing, children draw upon this prior learning. Finally, it is worth considering how the children use the textbook. After exploring the anchor problem, the children consider the solutions proposed in the text book and compare it to what they have been doing. In place of teacher explanation, Rosie prompts the children to read the textbook and use it to refine their ideas. In this way, the textbook almost becomes a guided reading book that the children can use to learn about mathematics.

SECTION 2: How might a mastery approach require change in teacher beliefs?

This second section provides another video lesson in which the teacher, Paula, is using a mastery approach, again based on the Maths – No Problem! scheme. In this case we try to shift the focus beyond lesson structure and teacher strategies to focus more on teacher beliefs about the nature of mathematics, expectations for themselves and for their children about developing as mathematicians and about the problem of in-class grouping or setting based on prior attainment.

Before watching the second classroom video, especially if you are unfamiliar with the research evidence on the impact of in-class grouping and setting by prior attainment, then it is worth considering the teaching and learning toolkit to get an overview (EEF, 2017). In-class grouping and setting is embedded in cultural beliefs and school practice in England and so it might be challenging to consider that the evidence base is so wide open. In general, the research evidence on in-class grouping and setting suggests only a minor overall positive impact with the benefits focused on children placed into higher sets and a clear negative impact on children placed in lower sets. In a research review on the impact of in-class grouping and setting by prior attainment, 7 possible causes of low attainment by students allocated to low sets or streams were identified:

1. misallocation to groups;
2. lack of fluidity of groups;
3. quality of teaching for different groups;
4. teacher expectations of pupils;
5. pedagogy, curriculum and assessment applied to different groups;
6. pupil perception and experiences of 'ability' grouping, and impact on their learner identities;
7. these different factors working together to cause a self-fulfilling prophecy

(Francis et al., 2016).

This research evidence is challenging because of cultural myths about maths widely held in the UK and America but less so in South Asia. That maths ability is inherited, that maths attainment is a sign of general intelligence, and that maths is about speed and calculation. In our research we found that the teacher researchers, through adopting the mastery approach scheme, seemed to be changing their embedded beliefs. The teachers changed their perception of themselves as mathematicians and raised their expectations that all children could reach a high standard in maths. They no longer believed that in-class grouping was necessary and switched to working in mixed pairs and whole class discussion. They also changed their view of what maths is about. They focused on the multidimensionality of maths (Boaler, 2016) and placed less emphasis on speed and calculation. The teachers showed signs of changing their mathematical mindset, in line with contemporary thinking about the malleable nature of intelligence (Boaler, 2016). Whilst acknowledging that children do have different cognitive capabilities, Mindset Theory argues that 'the more you practice, the more intelligent you get' (Dweck, 1999; 2006; Hymer & Gershon, 2015).

As follow-up reading to the video lesson you will find the open access research paper from our project useful (Boyd & Ash, 2018).

The second video, of Paula's lesson, is 17 minutes and is available at https://vimeo.com/232632133/ec9828cb7c

During the video of Paula's lesson, you might consider the following questions:

- How is the use of deliberately mixed pairings of children similar or different to my own classroom practice?
- How are high expectations for all children communicated through lesson structure and teacher facilitation?
- How are children with high prior attainment in maths being stretched during this lesson?
- To what extent do you feel there is effective learning in this classroom?

Paula teaches an unfamiliar class of children. Because they are using the maths mastery scheme with which she is familiar, she is able to plan and facilitate the lesson effectively without having to prepare different tasks for children with different prior attainment. She avoids in-class grouping and during the exploring phase of the lesson encourages the children in mixed pairs to consider her questions and share their thinking.

In the first half of the lesson Paula projects selected images from the text book onto the board to support her introduction to the problem, rather than requiring the children to open their textbook. She frames the maths problem as a debate between 'some of the children' and blurs the distinction between real live children in the class and the characters in the textbook. Paula supports journaling by the children as they consider how to prove or disprove that figures with the same area may have different perimeters and vice versa. She uses journaling throughout the exploring phase of the lesson and shows how the general lesson outline is somewhat flexible in practice.

In the interview Paula argues that 'it is important that all children struggle and make mistakes during the lesson…to appreciate the process of learning rather than achieving an answer to a question…'. Rather than quickly answering questions she suggests that 'maths is more about thinking and having strategies for solving different problems…'. These reflections indicate Paula's changing beliefs about maths and about mindset, and this has implications for her attitude towards the need for in-class grouping.

About half way through the lesson Paula introduces the guided practice tasks in the text book. She values the text book because it provides carefully designed tasks that include variation, meaning that working through the tasks gradually raises the level of challenge and checks understanding. She sees her planning as now being less about preparing materials and more about maths subject knowledge as she considers the purpose of the lesson and the different directions in which the children might take the anchor task.

At one point Paula handles a child's contribution by emphasising the need for a mathematician to communicate their thinking clearly. This picks up on the idea of multidimensionality of maths, meaning that being a mathematician is about more than 'executing procedures correctly' and includes, for example, asking good questions, making connections, and using different representations (Boaler, 2016:121). As some of the children get close to completing the guided and deep practice tasks in the text book, Paula introduces a challenging extension task to the class. This task remains focused on the same key concepts and aims to deepen learning rather than move on to the next topic.

Paula feels that her involvement in the research project, including the critical evaluation of classroom video clips, has increased her confidence in her maths teaching and in her willingness to consider the impact of classroom practice of herself and of colleagues. She considers the practical usefulness of theory in understanding not just what works but also why. In her closing comments Paula demonstrates empathy for teachers who are not confident about maths teaching but importantly feels able to support their development as a subject lead. She notes the significance of a teacher's mathematical mindset and how that might influence their children's beliefs about mathematics.

Having reflected on the two lessons, we would like to concisely summarise the findings of our small-scale qualitative study of Maths – No Problem! lessons, which was based on collaborative analysis of classroom video with teacher researchers. We found that in their lesson planning, supported by the scheme's text books and teacher guidance, the teachers appear to focus on maths subject knowledge as they anticipate how children might take different directions in exploring the 'anchor problem'. Our analysis suggested that teacher beliefs moved away from dependence on in-class grouping by prior attainment and shifted towards a malleable conception of intelligence in the context of maths. The study usefully considered the contested concept of growth mindset as domain specific, as situated mathematical mindset: a belief held in varied ways by teachers and children, that the more you practice at the edge of your current attainment level in maths, the more intelligent you will become as a mathematician (Boaler, 2016).

SECTION 3: What does research evidence tell us about the impact of mastery maths?

We would argue that in the field of education it is more appropriate to 'develop research-informed practice' than to naively assume that it is possible to 'implement evidence-based practice'. In a large-scale study of primary schools in England using a mastery approach influenced by Singapore maths, a modest impact on learning was identified (Jerrim & Vignobles, 2015; EEF, 2015). However, importing strategies from other cultures is not straightforward. A useful study investigated the maths achievement of western born children of East Asian descent living in Australia and showed that they performed more strongly in maths no matter what teaching strategies were used in their schools (Jerrim, 2014). It has been argued that importing an approach to maths is not likely to be effective because of cultural differences (Wong & Lee, 2009) although it should be noted that the Singapore maths approach was developed through critical engagement with international theory and research.

The professional field of 'education' is 'multi-disciplinary' because it combines the subject disciplines of philosophy, history, sociology and psychology. It is also multi-paradigm, meaning that in studying a particular issue, for example children off-task in my classroom, I will find several very different theoretical perspectives within the field that offer different explanations and strategies. Finally, and perhaps most significantly, the practical wisdom of teachers is highly valued knowledge which is essential if you are to understand formal education, but such knowledge is situated, meaning that it focuses on what works for a particular teacher or team in their school with the children from that community.

Practical wisdom is powerful knowledge but it is not easy to gain. Consider the 'knowledge' required to learn to drive a car. Think how hard it would be to 'tell' a complete beginner how to drive a car. We would argue that effective professional learning for teachers, learning that leads to change in classroom practice, requires interplay between theory and practical wisdom. This kind of interplay is promoted by sustained professional inquiry projects involving classroom experimentation and evaluation and adopting a critical stance towards both theory and practical wisdom (Boyd, Hymer & Lockney, 2015).

These ideas around knowledge within the professional field of 'education' are important because teachers, other school leaders, and policy makers in education need to be 'research literate', so that they might come to know what works but also approach some understanding of why it works. Some observers suggest that education should be evidence-based and compare it to the field of medicine. But education is more like the field of 'healthcare' or of 'mental health care' (Philpott, 2017).

Research meta-reviews have been influential and many head teachers use them to identify priorities, meaning that when reviewing the school improvement plan they consider which classroom interventions have been shown to have a strong positive impact on learning outcomes. This is an appropriate use of these meta-reviews of research, such as the work of John Hattie (Hattie, 2009; 2012) and the online open access Educational Endowment Fund online teaching and learning toolkit (EEF, 2015). However, these sources of evidence must be treated with care, because they select and collate randomised control trial research evidence on the impact of particular interventions. This provides useful evidence about what works, but does not investigate in depth as to why it works. Smaller scale and in-depth qualitative studies will be useful to inform the detailed implementation of the intervention. Local action research will help to mediate the intervention effectively to suit the local context. High quality professional guidance is also very useful, if it is scholarly and helps to broker the research evidence, making it accessible to teachers and relating it to practical classroom strategies.

In developing a mastery approach maths, we would suggest that a good starting point is to engage with the EEF toolkit meta-review and consider the evidence on mastery approaches. Due to the complexity of classroom teaching it is also worth using the toolkit to consider the evidence on feedback, collaborative learning, peer tutoring and metacognition. We have found Jo Boaler's work extremely helpful, including her research on the impact of mastery maths strategies in the classroom (Boaler, 2008) and then her outstanding professional guidance book for teachers 'mathematical mindsets' (2016). Above all we would encourage you to pursue professional inquiry, a practical and pragmatic form of action research, in collaboration with other teachers (Baumfield, Hall & Wall, 2013). In our small-scale research and development project the teacher researchers found the analysis of classroom video from their own and each other's classrooms to be a powerful process of professional learning.

SECTION 4: How might a school or alliance go about developing mastery approaches?

This final section suggests how you might go about developing a mastery approach in your school or alliance. There are a number of important principles to consider when designing a project and these are supported by research review on effective professional development for teachers (Higgins et al., 2015). These broadly consist of: time and rhythm to allow sustained engagement including classroom experimentation and evaluation; a focus on children's learning preferably within a curriculum subject; the needs of participants; alignment of approach and rationale; building trust and providing opportunities for collaboration; external specialist input; and support from school leaders. Bearing in mind the importance of time and rhythm, it is vital that professional development to support implementation of a mastery approach is given sufficient priority and a place in the school's schedule and development plan. We would argue that it requires at least one full year as a prime whole school focus, with time spent in subsequent years continuing to embed and refine practice. The Deep Learning teaching school alliance Maths – No Problem! Implementation project includes three main elements: core training; classroom coaching; and year group mentoring. The table below outlines the rhythm of these CPD activities.

Table 2. Key elements of the professional development project.

Core Training (initial 2 days) These two days were accessed by every teacher in schools and consisted of input from external specialists who used a demonstration and coaching model of training to help participants understand the core principles of mastery. Example lessons were taught to participants and then time was provided for reflective discussion facilitated by the trainers. Practical advice was given about how teachers could follow up on the training.
Classroom Experimentation (3 weeks) Participants were then left for a period of about 3 weeks to have time to experiment with what they had learnt on the core training days.
Classroom Coaching and Year Group Mentoring (several months) Classroom coaching involved teachers leading a lesson accompanied in the classroom by a specialist leader consultant. Guidance on areas for development was offered in a coaching style from specialists during the lesson and often lessons would end up being co-delivered by teacher and consultant. Time was provided for reflective discussion between teacher and consultant both before and after the classroom coaching session. Year group mentoring consisted of bringing together a number of teachers from the same year group, from different schools in the area, for an afternoon. A specialist leader consultant facilitated each session and time was spent un-picking issues that teachers were having as well as reflecting on lessons they had recently taught. Usually, a lesson was planned together that each teacher would go and teach the next week.
Core Training (Final day) After a period of about two terms (since the initial core training), participants would have one final day of core training. This day focussed upon refining practice and developing a deeper understanding of the principles of mastery.

It is worth highlighting a number of key issues that schools or alliances are likely to face. Firstly, it is vital that school leadership are dedicated to developing mastery and that they play an active role in its development. For this reason, the project described here also offered Head Teacher and Subject Leader update sessions. Secondly, it is vital that specialist leadership consultant capacity is developed to cope with the needs of schools in the area. As part of this project, it was a key priority to identify and train teachers who displayed an ability and desire to become a specialist. Finally, it is important that all CPD participants are treated as co-creators of knowledge. This means that, although there are specialists leading the CPD, it is clearly communicated that new participants are likely to develop mastery approaches further in their own setting and may well end up contributing to the development of practice in the future.

Websites

Deep Learning Teaching Schools Alliance http://www.deeplearningtsa.co.uk/

Learning, Education and Development (LED) Research Centre www.cumbria.ac.uk/LED

Maths - No Problem! https://mathsnoproblem.com/

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