Kingsland CE Primary School

Teaching for Mastery Mathematics

Teaching for Mastery Mathematics – the background

Mastery learning is not a new idea. Its origins can be traced to the early work of Benjamin Bloom (Bloom, 1971a, Bloom, 1968, Bloom, 1971b). In 1990 a meta-analysis of 108 mainly USA studies of the effectiveness of mastery learning concluded that it raises achievement (Kulik et al., 1990). The effects appeared to be greater for lower achieving students and they depended on a number of factors, including which mastery procedures were used.

Here in England, the NCETM and Maths Hubs are now promoting mastery approaches to mathematics, drawing on practices in east and south-east Asia. NCETM and Maths Hubs, provide extensive web-based advice on mastery in mathematics.

Teachers are currently making sense of mastery in mathematics, some in the belief that there is an agreed definition being used within the English school system and that this definition is based on a meaning derived from maths teaching and learning in some high performing jurisdictions, in particular Shanghai and Singapore.

Mastery goal orientation is defined by Carol Dweck (Dweck, 1986) as one where learners seek to develop their competence by acquiring new skills and mastering new situations, with a focus on personal improvement and development. This is contrasted with a performance goal orientation where learners seek to demonstrate and prove their ability to others in order to receive favourable judgments and avoid negative judgments. A mastery goal orientation is indicative of a growth mindset and is not dependent on a particular curriculum.

There are clear links between a mastery curriculum, mastery teaching and mastery goals but the suggestion of a mastery level in assessment, above what is expected, is problematic due to the conflict between this idea and the idea of a mastery curriculum being one where all children learn what is expected. The analysis of mastery mathematics in high-performing countries shows that the intention is to provide all children with full access to the curriculum, enabling them to achieve confidence and competence – 'mastery' – in mathematics' (NCETM, 2014). Bloom (Bloom, 1968) suggested that there were only two judgements to make in terms of assessment in a mastery curriculum, mastery or non-mastery, with non-mastery accompanied by detailed diagnosis and prescription of what is yet to be done before mastery is complete.

Teaching for Mastery describes an emphasis on success for all and that this can be achieved by developing conceptual understanding in mathematics, with a focus on mathematical structures. It advocates keeping the whole class together, not moving on until ideas are understood and promoting understanding through a variety of representations.

Teaching for Mastery Mathematics – differentiation

There is a misunderstanding that when using a mastery approach, all students must be doing exactly the same work, with no differentiation for groups or individuals. This probably stems from ideas of keeping the whole class together working on the same topic. The National Curriculum programmes of study state:

... the expectation is that the majority of pupils will move through the programmes of study at broadly the same pace. (DfE, 2013).

Additionally, Debbie Morgan, NCETM Director for Primary, states that two of the seven broad characteristics of teaching for mastery are ‘Teachers communicating their expectation that all pupils (except those with extreme special needs) will achieve’ and ‘Keeping the whole class together on the same material.’ (Maths Hubs, 2015a)

These statements could imply that all children will receive the same provision and the expectation is that they will achieve equally. However, the National Curriculum also suggests that pupils should be moved on only when they are conceptually ready and that pupils who have grasped concepts will be given ‘rich and sophisticated problems before any acceleration through new content.’ (DfE, 2013). This demonstrates that, within the curriculum, there is clear acknowledgement that not all children will develop a particular concept at the same time.

According to Charlie Stripp, Director of NCETM, one of the most common perceptions of differentiation in Primary School Mathematics in England involves provision of different tasks within a lesson according to perceived ability (Stripp, 2014). Compared to other countries, the UK has a slightly bigger gap between the highest and lowest attaining students in mathematics (PISA, 2014). Bloom suggests that dividing the class or year group according to perceived ability, becomes a fulfilling prophecy concerning students’ outcomes (Bloom, 1968). This concern is echoed by Dweck (Dweck, 2012) whose work suggests a link between mindset and attainment.

Teaching for Mastery on the NCETM website refers to ‘meeting the needs of all pupils without differentiation of lesson content’ (Stripp, 2015). This suggests that differentiation which requires teachers to produce different content for perceived ability groups, is incompatible with mastery. This fits with a view that mastery learning is about efforts to reduce variation in student achievement and close achievement gaps (Guskey, 2009). The NCETM page goes on to clarify what differentiation might look like within a mastery curriculum. It is suggested that differentiation is not through subject content but through urgent intervention for those children who are not meeting objectives and, for those who have rapidly grasped the concept, enrichment rather than acceleration. Charlie Stripp, Director of NCETM, states that differentiation ‘can be achieved by ‘same day intervention’ and ‘incorporating skillful questioning within whole class teaching’ (NCETM, 2015a). The theme of ‘same day’ or ‘rapid intervention’ also appears in books and articles e.g. (Drury, 2014), (NCETM, 2014).

Differentiation therefore can exist within a mastery approach and these appear to be the key strategies:

- Skillful questioning within lessons to promote conceptual understanding (Drury, 2014, Jones, 2014, Guskey, 2009)

- Identifying and rapidly acting on misconceptions which arise through same day intervention (Stripp, 2014, Maths Hubs, 2015a)

- Challenging, through rich and sophisticated problems, those pupils who grasp concepts rapidly, before any acceleration through new content. (NCETM, 2014)

- Use of concrete, pictorial and abstract representations, sometimes linked to levels of conceptual development (Jones, 2014, Drury, 2014).

This last point is sometimes linked to differentiation and to a view that ‘less able’ children are more likely to need ‘concrete’ apparatus, while more able children can move straight to a pictorial or even abstract representation. In our view, skillful use by teachers of a variety of

representations for pupils, enabling pupils themselves to represent mathematical in different ways, is part of effective teaching. Whereas, a rigid view of the suitability of particular representations for particular pupils is linked to a fixed ability self-theory (Dweck, 2000) and hence not conducive to pupil effort and to learning.

Teaching for Mastery Mathematics – the curriculum

A curriculum alone cannot provide a mastery approach. The notion of curriculum coverage is deeply embedded in UK practice. However, it is the teacher who covers the curriculum, not necessarily the learners. In a mastery approach, by contrast, it is the pupils who learn the topics in the curriculum. Many children currently do not learn all the topics taught to them; there are gaps. This implies that more time should be spent on those topics and there should be a reduction in the number of concepts covered.

This leads to one of the key features in some descriptions of a mastery curriculum for mathematics - reducing the number of mathematical topics handled in class, taking longer over each one, allowing all children to make sense of the mathematics (NCETM, 2015a). Bloom emphasised the importance of time for individuals to learn:

We believe that each student should be allowed the time he needs to learn a subject...The task...is to find ways of altering the time individual students need for learning as well as to find ways of providing whatever time is needed by each student. (Bloom, 1968)

The reduction in the number of concepts taught in Key Stage 1 will support mastery, if used with mastery approaches to teaching and learning. This secure foundation at Key Stage 1 could then enable concepts to be developed more easily as children get older. Furthermore, the stated aims of the current National Curriculum imply that mastery is intended. Hence the National Curriculum for Mathematics (2014) has been described as a ‘mastery curriculum’ (NCETM, 2014).

Some descriptions of a mastery curriculum for mathematics include a focus on small steps in the design of the curriculum:

Effective mastery curricula in mathematics are designed in relatively small carefully sequenced steps, which must each be mastered before pupils move to the next stage. Fundamental skills and knowledge are secured first. (NCETM, 2014)

A variety in representations of mathematical ideas is valuable, but inflexible use of different representations is not helpful. This applies to curriculum as well as to teaching. A curriculum that rigidly requires pupils to engage with concrete, pictorial and then abstract approaches to every concept is not necessary for mastery.

In a recent blog, Charlie Stripp, Director of NCETM, makes the point that because of the inbuilt expectations, the new National Curriculum is a mastery curriculum. He makes the point that mastery relates to depth of understanding and that can only come from skilled teachers with a sound understanding of mathematics who have adequate time and resources available to teach children to the depth of understanding that is needed. This will not happen if the focus is on covering all the curriculum content – a legacy of the old curriculum and the pressure put on schools to secure ‘progress’ and to generate data for use by others.

Teaching for Mastery involves a curriculum that is flexible, employs problem solving as an integral part, aims for fluency with understanding and supports the development of mathematical reasoning.

Teaching for Mastery Mathematics – intelligent practice and variation theory

There is a false idea that mastery relates only to mechanical procedures, rather than to concepts. Coupled with the idea that to master a procedure requires repeated practice at that procedure, this leads to the belief that a mastery approach to mathematics requires repetitive practice with little variation in the items practiced for any particular procedure. This is not the case.

Notions of effective practice for students were given in The Cockcroft Report (par 239) (Cockcroft, 1982). Here, a clear distinction is made between fluency that is built on understanding, and purely mechanical performance which does not in itself lead to long term retention or transfer of use to other contexts.

Para 239: ...we need to distinguish between 'fluent' performance and 'mechanical' performance. Fluent performance is based on understanding of the routine which is being carried out; mechanical performance is performance by rote in which the necessary understanding is not present. Although mechanical performance may be successful in the short term, any routine which is carried out in this way is much less likely either to be capable of use in other situations or to be retained in long term memory.

Teaching for Mastery does not advocate the sort of practice that is short term and aims only at short term memory, rather than at conceptual understanding. Professor Malcolm Swan states:

If practice is just repeating the same procedure with different numbers, chosen randomly, then it has no purpose. Some appear to think that such practice is like training a muscle, where repeated exercise builds up some kind of inner mental strength and speed. In fact it usually results in boredom. Variation theory tells us that by systematically changing significant aspects of a task, keeping the rest fixed, we can focus the students' attention on those aspects and conceptual change can result. But the emphasis in making such variations is not to develop speed but to develop an awareness of pattern, leading to conjecture, generalisation, explanation and deeper understanding.

This systematic changing of aspects of a task is key to designing effective practice activities for children. This point is made by Anne Watson and John Mason:

Our conclusions after three years of work in a range of natural settings are that control of dimensions of variation and ranges of change is a powerful design strategy for producing exercises that encourage learners to engage with mathematical structure, to generalize and to conceptualize even when doing apparently mundane questions. (Watson and Mason, 2006).

Furthermore in China, procedural variation is used to promote deep understanding of mathematics (Lai and Murray, 2012). So the types of practice promoted by mastery in mathematics include use of a concept or procedure in a variety of contexts.

Using an analogy with musical practice, mathematical études consist of mathematical tasks which embed the practice of essential techniques within a richer, exploratory and investigative context (Foster, 2013). Such mathematical tasks are focused on developing genuine fluency in skills, based on conceptual understanding and through extensive opportunities for rehearsal alongside more thoughtful and mathematically creative activity.

In summary, there is a danger that superficial repetitive practice becomes simply a mechanical exercise, quickly lost in memory and difficult to apply in different contexts. However, where practice is developed in an organised way to create focus on a higher level of understanding then such practice becomes particularly useful.