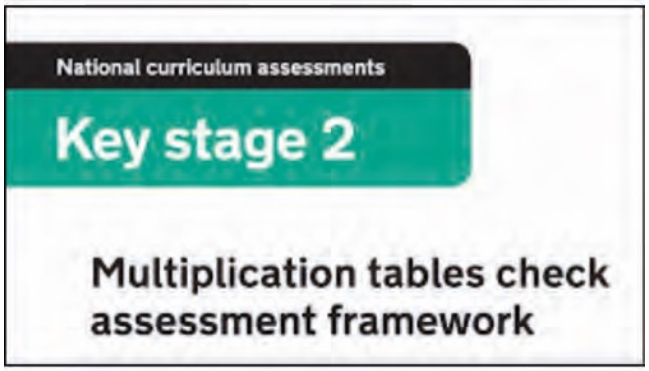
A whole school intervention for teaching, learning and understanding times tables

Jenny Field discusses her regional action research project, delivered to over 120 maths leads across 5 local authorities

Why I designed this year-long intervention project

In 2014 Minister of State for Schools Nick Gibb stated that '*Nine-year-olds should recite times tables by heart',* knowing all their tables up to 12 x 12 two years before completing primary education. In many ways this was nothing new. Since the introduction of the National Curriculum children have been expected to know their times tables by the end of lower KS2; however, what was new was that this announcement was to be a precursor for the introduction of a new Year 4 statutory times tables test from 2020, the Multiplication Tables Check (MTC).



At this point, before I move on to a more positive approach, I must admit that my first reaction to this news was '*Oh no!'* I have two clear reasons for this; firstly I am not a fan of individually timed maths questions. It seems to me that maths is the only subject in which expertise and speed appear inseparable. You are unlikely to hear '*What is the capital of Switzerland? 5, 4, 3, 2, 1 … shame, you're no good at geography!*' yet individually timed questions in maths are commonplace. A key problem with this is that in stressful situations, cortisol is released into our brain which interferes with learning and memory (Ackermann et al 2013); hence why in a stressful situation, for example, presenting to a large audience, we can sometimes '*go blank'*. I also know from my own experience that when faced with a 6 second countdown I find myself focussing more on the ticking clock than the question itself. This is not conducive to assessing current ability and so while I understand the need for a test to have an overall time, I believe individual question timing is more problematic. As Boaler (2016) rightly states '*One thing we need to change in mathematics classrooms around the world is the idea that in mathematics speed is more important than depth*.'

The second reason for my initial negativity was that I do not wish to see a return to the old ways, which from my own experience meant tedious '*drill and practice*', being '*put on the spot*' by teachers pointing fingers, and having little understanding of what I was learning or why. I was often the one with the fish mouth, moving in time with the class without knowing the words, which did nothing to improve my love of maths at that time.

All that said, I have always believed that children *should* have recall of their times tables. Not at breakneck speed – even Marcus du Sautoy, a great contemporary mathematician and Professor of Mathematics at Oxford admits that he is '*not terribly fast*' with times tables (2008) – but yes, fairly quick recall. I also believe that not having that retrieval increases cognitive load and impedes children's ability to move on to more interesting maths; so a more pragmatic approach then led me to the conclusion that although I was unlikely to be able to influence

the first of my concerns, I could do something to make a change in terms of the second. I reflected that I had never, in over 3 decades of observing maths lessons, seen a lesson solely dedicated to the deeper understanding of one specific times table, nor seen any real structure and shared understanding in the teaching of times tables across a school. In fact, as Richards (2015) states, times tables have been more likely to be set as an activity for homework or subliminally learnt almost via osmosis by exposure to mathematics more generally over time; yet we often hear teachers say with frustration '*they just don't know their times tables*'.

Since 2017 I have gathered research data from over 100 schools which strongly supports my initial hypothesis that in the specific area of teaching, learning and understanding times tables, schools are unlikely to have a whole school structured approach, ownership of the curriculum or consistent shared beliefs about good practice. Of course this is understandable when they have so many other competing priorities, but is also likely to be unhelpful, as an ability to understand and manipulate times tables supports children in so many other aspects of mathematics. In addition, the new Ofsted framework (2018) has an increased focus on schools taking more ownership of curriculum development, making this a perfect opportunity to design professional development which support schools in structuring of their own research-based curriculum for times tables.

Memorisation versus automaticity

A recent report from the Organisation for Economic Cooperation and Development (2019) draws upon PISA research to demonstrate that of all the OECD Countries, the UK appears to have the highest use of memorisation, rehearsal and repetition, and the third highest in using '*learning by heart*' as a strategy. It could be argued that the current perceived need for the MTC demonstrates that this path has not got us very far. In a recent Primary Mathematics journal article, Parker (2019) relates the collective views from the joint Primary Group of the Association of Teachers of Mathematics and the Mathematics Association, and their concerns about memorisation. She states that although they do recognise the importance of children having recall of their multiplication facts, they are wary about an emphasis on *'rote learning and rapid recall over understanding of mathematical structures'* (p3).

The stated purpose of the Multiplication Tables Check (MTC) is to determine '*whether year 4 pupils can fluently recall their multiplication tables'*, but it is important to remember that the NC clearly states that *'fluency and conceptual understanding are developed in tandem because each support the development of the other';* and in 2014 Jane Jones, then HMI National Lead for Mathematics, said in an NCETM blog … '*fluency (that blend of conceptual understanding and procedural flexibility) …capture(s) the best in mathematics education that we would surely want for any pupil.'*

With this in mind, and the preconceived notions when we talk about memorization, rote learning or learning by heart, perhaps it would be better to use the word '*automaticity*' instead. Fosnot and Dolk (2001:85) describe the difference here, '*Memorization of basic facts usually refers to committing the result of operations to memory so that thinking is unnecessary … Teaching facts for automaticity in contrast relies on thinking. Answers to facts must be automatic, but thinking about the relationships among the facts is critical. A child can then think of 9x6 as (10x6)-6'.* This definition was uppermost in my mind when I designed this project.

The project

In 2017, in partnership with the South East London Maths Hub, I designed and introduced a year-long action research project '*Whole school approaches to teaching, learning and understanding times tables'* funded by the Hub as an innovation project. The project is now in its third year.

Having been a programme leader for MaST as part of the South East England Consortium (The DfE Mathematics Specialist Teacher Programme 2009–2014) I feel strongly that an extended approach has more impact than '*one off*' CPD. Gap tasks and professional learning logs also create rich opportunities for expert networks to develop. The project is aimed at mathematics leaders with the intention of creating accessible, structured '*Whole School Steps'* for discussion and dissemination. The project has been oversubscribed every year – with several academy trusts sending all their Maths Leads. I believe this demonstrates a current need for access to this type of CPD nationally. The project itself has been very well evaluated and has evolved over time. Each year I have used the data from participants to improve the content and design.

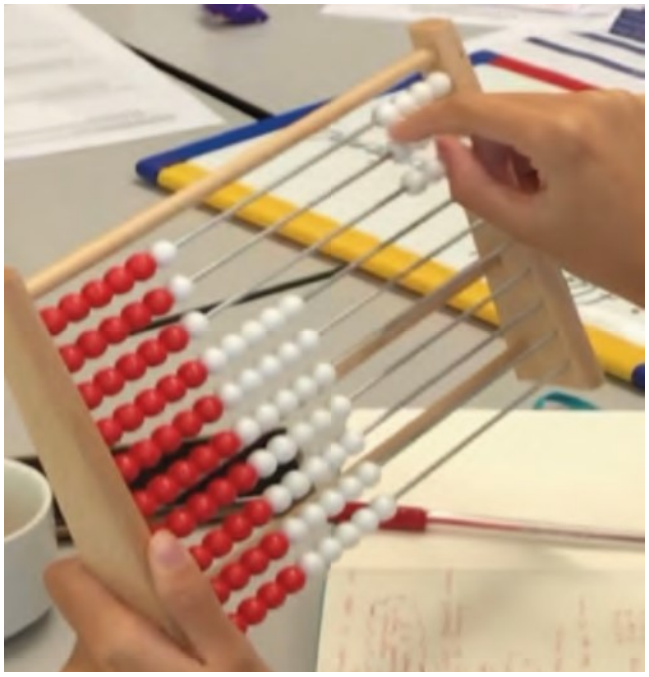
Brief overview of structure and content

I will now offer up some of the key features of this project – you may well think of other aspects for inclusion, but hopefully this will whet your appetite and stimulate some rich conversations.

Firstly I advocate focussing on each 'new' times table for a half term. I was fortunate enough to spend two years studying at Oxford University, looking at research into neuro plasticity. I discovered that the formation of a new neural pathway takes approximately eight-ten weeks. This time allows for the early formation of a myelin sheath around this pathway which contributes to automaticity – making it a '*go to*' place for recall. If we initially jump about with times tables, without prolonged focus, then this formation is less likely.

The project has two distinct components in terms of time distribution:

Component 1: Regular retrieval practice to develop fluency (5–10 minutes 3–5 times a week) Piazza and Dehaene (2004) set out the process of storing facts in our verbal memory. An emphasis on saying (and hearing) the sound pattern of the phrase is important and can lead to verbal prediction and patterning – however this practice can and should include conceptual support.



Component 2: Approximately 3 dedicated whole maths lessons every half term to explore each new times table – developing connections, exploring patterns and creating a deeper understanding of multiplicative reasoning with specific focus on this new times tables.

The project structure itself currently comprises **4 Pre-requisites and 8 whole school steps**. The Pre-requisites allow participants to consider what children must know about multiplication, at the very least, before they embark on learning times tables. The pre-requisites I consider most important for this project are:

- unitizing;
- understanding equal and unequal groups;
- combining equal groups;
- understanding the early relationship between repeated addition and the times sign.

Once we have spent time considering how we support children to develop these prerequisites (including the use of NCETM Professional Development Materials), we move on to the 8 Whole School Steps, designed to bring some consistency and progression across the school.

I will now briefly set out each of these 8 Steps:

Step 1

Decide the **order** in which your school will teach the times tables, **which tables** will be included and **why.** As part of this I offer up my own ideas which they can discuss and adapt. Teachers need to know which times table they are responsible for exploring, to consider the importance of the 1× table and to build in additional opportunities to regularly revise what has been previously learnt.


How I might plan it …discuss

Focus on **ONE times table each half term** – with opportunities built in to also practise those learnt previously

YEAR	First half term	Second half term	Third half term	Fourth half term	Fifth half term	Sixth half term
Year 1	Experience of counting in 1s, 2s, 5s, 10s					
Year 2	1×	(1×) 2×	5×	(5×)10×	0×	revision
Year 3	(2×) 4 ×	(4×) 8 ×	3×	(3×) 6×	(6×) 12×	revision
Year 4	9×	7×	11×	Squares	revision	Test: June

Why a focus one TT per half term? Plasticity of the brain

Neuroscientists tell us it takes approximately **8 weeks of repetition to make a new neural pathway with a myelin sheath** – making this 'go to' automated thinking! Then continued practice makes the sheath thicker

Step 2

Have a clear rationale for the way you *present* your times tables for learning – is x6 or 6x the 6 times table? Guidance for the MTC states that 6×7 is in the 6× rather than the 7× table. Of course in abstract situations this is of little consequence,

but with a concrete problem it takes on a new meaning, therefore school consistency in rationale, presentation and understanding are important. AND choose the *common language* to be used across your school and why. From my research there is too much inconsistency and confusion here.

Step 3 (component 1 and/or 2)
When you introduce a new times table *systematically build it together* with the children around the facts that *they already know* and have met before.

Step 4 (component 1 and/or 2)
Introduce a new times table by first making clear conceptual links to the real world – a half termly display of '*what comes in …*'.

Step 5 (component 1)
Regular retrieval practice to develop fluency (5–10 minutes 3–5 times a week). Provide teachers with a '*Bank of high quality activities for retrieval*' for coherence across the school.

Include conceptual support (at least initially)
Include full verbal patterning (saying whole calculation) and also step counting
First in order then out of order
Build in tests but NOT as the main activity

Step counting which supports understanding of the changing value of 1 finger – they can then shake cubes off and visualise them.

Step 6 (component 2)
When you introduce a new times table use the CPA approach for ALL children, but with consideration of the most powerful representation for exposing the properties and laws of multiplication, and enabling clear connections and deeper understanding. Choice of representation is not about quantity but about quality and progression.

Progression of the array, beginning with number blocks, features as a key model. Research by Barmby et al (2009) exposes the power of the array, strengthened further by research undertaken by Huntley (2019:7) stating that '*greater exposure to arrays will offer significant benefits'.*

Step 7 (component 2)
Take time to explore the many patterns within each new times table; repeating digits, reversing digits, addition of digits, divisibility and how each table relates to several other times tables.

Step 8 (component 2)
This last step is an overarching one, as it relates to all Steps and provides participants with opportunities to develop mastery through the use of variation (rather than variety) and through more intelligent practice as they plan the content of component 1 and 2.

Research findings

Anonymous pre and post data were gathered from participants to gain deeper insight into this process. Impact takes time, and when post questionnaires were completed the Maths Leads had only just completed the project and were beginning to implement changes; in some cases other priorities caused complications and some wanted to complete the whole project before going forward. However early impact data suggest that some positive change had already taken place. I have summarised here some key themes from questionnaires collected from 69 Maths Leads.

Pre-intervention Maths Leads were asked about their awareness of the way times tables were taught across their school. Only 10% felt fully aware, with 71% of participants feeling they had limited awareness and a further 19% with no real awareness at all. Post intervention only 4% were still unsure about how times tables were taught in their school and the percentage who now felt fully aware had risen to 68%.

Pre questionnaires demonstrated that 80% of schools had an individual teacher approach to teaching times tables; 12% didn't answer or were not sure; leaving 8% with a whole school approach. Post questionnaires demonstrated a real shift here, with 79% stating that they had a whole school approach, and the majority of others stating that this would be rolled out in the near future.

Post intervention 95% stated that there had been changes in the teaching of times tables, 100% felt that their subject knowledge had deepened and 84% said that subject knowledge of their staff had grown. In addition Maths Leads from cohort 2 undertook times tables test with their year 3 children pre and post intervention (circa 1500 children); 100% of children increased their scores over 5 months, and 75% saw their score increase between 11–30%.

Data also demonstrate key impact themes:

- long term high quality CPD made Maths Leads more confident when working with staff, creating opportunities for deepening subject knowledge and improving pedagogy;
- schools are more receptive when things are well structured in small steps and do-able;
- schools involved are now actually teaching times tables with a whole school approach which has improved consistency across the school (or are working towards this);
- children and staff found a focus on language to be, in the words of one participant, a '*game changer*'. One Maths Lead reported that a bright child suddenly said 'Oh *I've really got it now*', the ML found this interesting as she thought the child had already '*got it*'!

"The course itself has been inspiring. It has enabled me to pass on a joy of teaching times tables to my children and colleagues and enabled a deeper understanding of mastering tables and mathematical concepts."

Where next?

2019 has seen a new cohort of 50 Maths Leads (across 5 Local Authorities) join the Project. Regional and national interest is growing and I am currently working with the NCETM who are considering a national times tables project for all Maths Hubs. Some larger national academy trusts, (including United Learning) are rolling out this project and so have joined a new '*Train the Trainer*' Programme, all of which has been very encouraging. Improvements can still be made, lessons can be learnt, but hopefully the project has been worthwhile.

Over the years I have known too many children who could speedily recall multiplication facts yet when presented with any real-life context had no clue – making the MTC a false indicator of mastery. We want children who are not just problem solvers but problem posers, with an ability to manipulate and to make connections; children who not only recall $7 \times 4 = 28$, but more importantly know commutative and inverse facts, mini and mega fact e.g. $70 \times 4 = 280$, $0.7 \times 4 = 2.8$, the distributive law – not just by place value but also by number bonds e.g. $(5 \times 4) + (2 \times 4) = 7 \times 4$, doubling and halving facts, and know that 4×7 is the same as $(5 \times 7) - 7$. Focussing on testing alone is unlikely to achieve this.

The National Association of Head Teachers (NAHT) has recently produced a report setting out several valid reasons for the removal of the MTC. It remains to be seen what will happen as a result. Whatever we feel about the new MTC itself, it has provided an opportunity for reflection and created impetus for strong school engagement where there has been less focussed attention in the past. How we choose to interpret this challenge in our schools will make all the difference. We must not return to drill and practice without understanding, or a '*Take it home on a Friday for a test on Monday*' whole school approach.

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Jenny Field is a Professor of Mathematics Education at the University of Greenwich

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