

# Can conceptual learning enable accelerated progress in times tables as opposed to rote learning?

## Orchard School, Lower KS2 Phase

### Abstract

The aim of this study was to differentiate between conceptual and rote learning and trial their effectiveness of enabling accelerated progress in times tables. A sample group of six focus pupils, from across Years 3 and 4, were selected to take part in a ten week daily times table intervention. Half of the pupils from the Year 3 cohort were given recurrent rote opportunities to recall multiplication facts in and out of order repetitively to enable effective memorisation. The other half of the children from the Year 4 cohort explored multiplications using a range of conceptual methods, such as: using arrays to recognise multiplication as commutative and as repeated addition; using knowledge of double to derive multiplication fact; understanding fact families to make links between multiplication and division.

Before the intervention commenced, the pupils were tested using iPrimary (online testing tool), which was used to calculate the percentage of correct multiplication recall and form a baseline. A group of times tables ambassadors were trained to conduct daily times tables sessions, lasting no more than ten minutes. After the ten week intervention, pupils were tested again using iPrimary, which was also used to calculate the percentage of correct multiplication recall and compare with the baseline in order to measure impact. The Year 4 Multiplication Tables Check (MTC) was also used as secondary data to further inform the conclusion.

### Introduction

The MTC became statutory for primary schools in the 2021/22 academic year. The Department for Education expressed that the check is part of a new focus on mastering numeracy, giving children the skills and knowledge they need for secondary school and beyond. The purpose of this check is to assess whether pupils can recall their times tables fluently, whilst identifying those who have not yet grasped it, (DfE, 2017).

Times tables are at the heart of mental arithmetic at Orchard. Fluent recall of multiplication facts can enable pupils to work more confidently through a wide range of advanced calculations. The school uses a variety of interactive, visual, conceptual and rote learning techniques to ensure pupil can achieve the full times table knowledge by end of Year 4. Every Monday, times tables are taught explicitly at the start of the mathematics lesson for at least ten minutes using a range of techniques to help children to understand the concept of times tables. This is followed by a two minute time table starter, taking place before every maths lesson between Tuesday to Thursday using a range of stimulating methods including the counting stick and chanting. Every Friday, pupils complete a times tables test in their books related to the times tables focus of the week and complete an online test (iPrimary) twice per half term which informs future teaching and teacher assessment.

Pupils require a range of methods to adopt basic skills. Rote learning is a commonly adopted method, which encourages memorising facts through repetition and rehearsal, (Meyer, 2002). Through repetition, pupils can acquire various facts, including times tables. Despite some arguments suggesting rote learning to be meaningless

and limited, (Boaler, 2015), many would argue it is still an essential and necessary technique when learning basic skills, developing fluency, a deeper understanding as well as accuracy of knowledge, (Sinhaneti & Kyaw, 2012). Furthermore, Math is like a language and basics of any language should be memorised before engaging in more interesting and conceptual conversations, (Mitchell, 2015). Memorising the basics of the four operations, may enable pupils to be far more fluent, efficient and engaged in more advanced concepts, (Mitchell, 2015).

Research suggests although learning mathematics facts through rote are important, the memorisation of math facts through times table repetition and timed testing is excessive and detrimental, (Boaler, 2015). There are limitations to memorisation without number sense and with it, pupil are able to use numbers flexibly, (Boaler, 2015). When asked to solve  $7 \times 8$  someone with number sense may have memorised 56 but would also be able to make links to  $7 \times 7$  and  $8 \times 8$  and then add/subtract 7 to make 56. Conceptual learning opportunities can develop number sense and deeper understanding of concepts. Through the use of concrete/visual manipulatives pupil can recognise patterns, number families, how multiplication is repeated addition and a commutative operation.

Gray and Tall, (1994) studied pupils from a range of abilities solving numbers problems and found out that the high achievers solved problems using number sense, for instance: changing  $19 + 7$  into  $20 + 6$ . Low achieving pupils on the other hand, solved subtraction problems such as  $21-16$  by counted backwards from 21 rather than changing the numbers into  $20-15$ . In conclusion, that low achievers are often low achievers not because they know less but because they do not use numbers flexibly. They have been memorising method instead of interacting with numbers flexibly, (Boaler, 2009). Conceptual learning can therefore create opportunities for deeper understanding of times tables and not just recall of facts. It can enable pupil to interact with numbers, identifying patterns and making links to inverse. It can also enable pupils apply what they already know and use it grasp new concepts.

## Research Process

The research was coordinated by the Lower Key Stage Two Phase Leader and the Times Tables Ambassadors, a group of trained pupils in Years 4-6. The intervention was delivered daily to a group of low attaining pupils from Years 3 and 4 for 10 minutes for ten weeks. A range of stimulating resources including commutativity models, arrays, flip cards and numicon were used to ensure Year 3 received continuous rote learning opportunities, whilst Year 4 unpicked multiplication facts conceptually. All sessions linked to the current year group weekly focus. Before the launch of intervention, all pupils completed an online test using IPrimary to form a baseline (see fig.2).

A rote learning session (fig. 1) was a quick introduction of the focus time tables, followed by counting in multiples back and forth, then repetitively chanting multiplication facts in and out of order. All sessions ended with a deliberate practice task. Only the main part of a conceptual learning session (fig. 2) differed, as it entailed exploring times tables to enable pupils to recognise number families and multiplication as commutative, as well as repeated addition. Concrete and pictorial manipulations (i.e. counters, cubes) were used to aide learning.

**Fig.1**

Introduce	Revise	Apply
6 x counting in multiples	Chant in and out of order ( $8 \times 6$ , $12 \times 6$ , $6 \times 8$ , $6 \times 12$ )	Hit the buttons
6 x counting in multiples	Chant in and out of order ( $8 \times 6$ , $12 \times 6$ , $6 \times 8$ , $6 \times 12$ )	X tables bingo
6 x counting in multiples	Chant in and out of order ( $8 \times 6$ , $12 \times 6$ , $6 \times 8$ , $6 \times 12$ )	Fortune teller

**Fig. 2**

Introduce	Revise	Apply
6 x counting in multiples	Using number line/100 squares	Hit the buttons
6 x counting in multiples	Repeated addition using arrays	X tables bingo
6 x counting in multiples	Numicon (link to 3x)	Fortune teller

At the end of the ten week intervention, all participants completed another online test using IPrimary and the results of this, as well as the scores from the Multiplication Tables Check (see fig 2) was measured for impact.

## Findings

The results show that all pupils, across Years 3 and 4, made progress (fig. 3) and those that had received conceptual learning opportunities have made more progress. Data from IPrimary and weekly times table tests completed earlier in the year suggests pupils were consistently performing below expected. However over the course of the year, data gradually increased and two pupils in Year 4 scored well above what was expected in Multiplication Tables Check.

**Fig. 3**

	IPrimary test 3 (%)	IPrimary test 8 (%)	Impact (%)	Year 4 MTC (%)
EC	3	37	34	
RD	13	60	47	
FDF	34	71	37	
IA	21	65	44	64
AA	43	91	48	96
AO	21	71	50	96

In addition, the perception of times tables improved considerably due to the positive change in pupils' attitude towards it. Pupil who took part in the research intervention displayed high levels of engagement. Five out of six participants expressed, they believe to have improved substantially due to the intervention. One pupil articulated, "counters make multiplying easier," with another expressing, "Numicon helped me see how similar the three and six times tables are." All pupils have conveyed that they now look forward to learning their times tables and most importantly, appreciated the experience of working with a times tables ambassador with one pupil stating, "My times tables ambassador challenged me to use number families to find missing numbers". The times table ambassadors, who displayed a clear understanding of the rationale, formed good relationships with their younger peers, felt empowered and motivated to ensure their intervention had impact.

## Impact and Conclusion

The research highlighted the significance of both rote and conceptual learning. Rote learning opportunities enabled a group of pupils to master their basic multiplications knowledge, develop automaticity, enabling facts to be recalled without having to think about it. On the contrary, conceptual learning, created opportunities for another group of pupils to master a concept by recognising patterns, understanding multiplication as commutative and making links to other operations (such as number families and repeated addition).

In conclusion, the data reiterates the prominence of learning times tables through conceptual as opposed to rote learning. Learning time tables is clearly more effective moving from concrete to pictorial, before abstract methods, reinforcing the findings of Bruner (CPA, 1966). Conceptual sessions reflected a good balance of concrete, pictorial and abstract learning, as well as including opportunities for rote learning, enable pupils to make better rates of progress. A suggestion for Orchard Primary School, would be to adapt their times tables policy to create daily standalone conceptual times tables session as opposed to the current structure of just rote recall to enable rapid rates of progress for all pupils across Year 3 and Year 4.

## References

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